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The Value of Practical Experience—I

In a letter printed in our last issue a correspondent raised the question of the difficulty of securing executive positions in the foundry for men who have not had actual floor experience in spite of metallurgical and managerial knowledge, and he suggested that it was time that the apprentice bogey, the necessity for direct practical experience, should be removed. The point is well worth examining, because there are in patternshops, laboratories and cost and estimating departments men who are of managerial timber. They lack direct foundry knowledge, but have the advantage of contact with the foundry, and, not being immersed daily in foundry production, often see more of the foundry as a whole, that is, as an operating unit, than the man actually on the floor. We include in this the relations of the foundry to its clients, to its suppliers of raw materials, and to the other departments of the works to which it is attached.

Let us consider the question in three parts. First, what is the ideal training for a foundry executive; secondly, how far is this met by various grades of people available to-day for executive jobs, and, finally, how far the industry would be justified in accepting our contributor's contention. We may preface this with the suggestion that if a man is a born foundry manager, so to speak, then it does not really matter by what channel he gets there. Sooner or later his obvious fitness for the job is recognised, even if he spent his early years as an arctic explorer. If we take the technical professions, where men have to have knowledge, to know how certain things are accomplished practically and to know how to lead other men, it is generally accepted that they should have a good education, preferably at a university, and then a spell of practical experience. An engineer has a definite works apprenticeship following his education, and the two combine to make a training. Doctors walk the hospitals during and after their course, and lawyers attend the courts for similar reasons. The feature of such apprenticeship is that it is carefully planned to give wide experience and manipulative skill without spending time on the repetition which is necessary for skilled artisans. Here we have to admit that in many cases apprenticeship for artisans is often much too limited and confined to a few points without giving the wide view of the whole. Where occupations demand more practical experience and less technical knowledge, such as shipbuilding or navigation, the school or university course is shortened and the apprenticeship lengthened. Wherever training for founding may lie in comparison with other occupations, it needs both these elements. The conclusion to be drawn must await the next issue.

When Should the Red Light Appear?

Last week, in conversation with the chairman of one of the largest groups of foundries in Great Britain, we learnt that there was a large body of thought which maintained that hot sand was not detrimental to the production of sound light iron castings. It is well known that the Perlit system utilises moulds controlled to certain elevated temperatures for high-duty castings. Other foundry owners have stated that hot sand is definitely detrimental to the production of high grade castings and practical results were cited both for and against. We pointed out that some firms had spent the equivalent of the capital necessary to float a medium sized foundry, just for the purpose of ensuring a regular supply of cold sand. The question naturally arises is hot sand really detrimental and, if it be so, there is need of further definition. For instance, what is meant exactly by hot sand; where, for example, does the dangerous range start? It is also essential to know whether the incidence of the danger point is the same for all sands. Is it a question of steam formation, which causes surface disintegration? It has been asserted that hot sand "bonds" are better than cold, as *hot* water has a more intensive influence on clay than *cold*. It is very obvious from a talk with a group of responsible ironfounders that far too much is being taken for granted. If there be a dangerous range, at what point does it start, and with what type of sands? Is it possible to work with some sands at relatively high temperatures and not with others? With the coming of the mechanised foundry, this point is obviously important, and we believe it can be taken for granted that there is a dangerous range. We are only too familiar with the experience certain foundries have had in this direction, and the success that has attended the expenditure they have made to cool sands, yet surely the industry has a right to know when the red light should be shown and whether, by using this or that variety of sand, the danger point is elevated or depressed. We are informed that such information has been experimentally ascertained, and, if this be so, we assure those in possession of the facts that our columns are open to the printing of such data, the publication of which can do nothing other than good for the whole industry.

The Warrington Light Castings Company

The foundry of the Warrington Light Castings Company, Limited, situated in Longshaw Street, was opened on Tuesday of last week by the Mayor of Warrington (Councillor J. T. Cooper, J.P.), who tapped the cupola, and made the first casting.

This company was originally started by Mr. Melton in quite small premises in 1919. The business was converted into a limited company with a capital of £10,000 in 1926, when larger premises were acquired in Napier Street. In December, 1935, the company entered into Federated Foundries, Limited—a group of nine firms located in various parts of England and Scotland.

The New Foundry

The Longshaw Street site is conveniently located alongside the London Midland & Scottish main line, from which sidings can easily be led in. It covers five acres, which will allow the present buildings to be doubled. The existing buildings consist of a foundry, dressing shops, patternshops, fitting and paint shops, which constitute the manufacturing plant, and there are separate buildings for the office suite, men's mess rooms, cycle garage, first aid room and modern lavatories.

The main building is 210 ft. by 150 ft., divided into three 50-ft. spans. The roof, which is considerably higher than most moulding shops devoted to the production of builders' castings, is of the saw tooth type with northern lights. The roof carries numerous ventilation cowls, and this system is usually quite successful.

The spacing of the supporting pillars is particularly wide, so that if in the future it should be decided to install a mechanised plant, there is both room and height for a centrally disposed system.

The cupola, which is to be duplicated, is of the solid-bottom type and driven by a Roots blower. Materials are taken to a spacious charging platform by an electrically-operated 10-cwt. Vaughan telpher suspended from a monorail, which passes over a weighing machine and past the charging door. Owing to the system of working, standard conditions have been maintained, that is, no moulding machines or sand-preparing plants have been installed, but the liquid metal and raw castings are handled by a complete system of Vaughan overhead runways. Lighting has received due consideration, and a new system designed to give 12 foot-candles is being tried out.

The great speciality of this foundry is the Melt-on ear for rain water pipes, a method invented by Mr. Melton and one which has been taken up by a large section of the light castings industry. A full range of builders' and plumbers' castings as well as a variety of cast-iron goods for the gas and electrical industries is also manufactured.

Opening Luncheon

A luncheon at the Horse and Jockey followed the opening ceremony. It was presided over by Mr. W. Rennie, chairman of Federated Foundries, Limited. Mr. John Plews, in proposing the toast of "The Town and Trades of Warrington," referred to the fact that Warrington was originally an industrial Roman settlement and not an armed camp. Mr. S. A. H. Mackay, the architect of the new building, presented the Mayor with a souvenir of the occasion. Mr. J. F. Harvey, proposed the toast of the Warrington Light Castings Company, and Mr. John Fairclough, the managing director, took the opportunity of thanking the directors of Federated Foundries for their benevolent acquiescence to all his proposals for extensions. The Town Clerk of Warrington proposed the health of the Chairman. Amongst those present were Colonel Macfarlane, Mr. John Cameron, J.P., Past-President of the Institute of British Foundrymen; Mr. J. M. Jackson, Mr. J. M. Primrose, Mr. R. A. Miles, and Mr. V. C. Faulkner, Past-President of the Institute of British Foundrymen, and Editor of THE FOUNDRY TRADE JOURNAL.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Expansion of Sand

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I was particularly interested to note the work done by W. Y. Buchanan in connection with the expansion of foundry sands and published in the JOURNAL for May 27. In view of his results being at variance with those obtained by Nilsson, Dietert and Valtier, and myself, it might be advisable to make some comment.

In the first place, it will be appreciated that in all dilatometric studies the type of equipment used determines to a very large extent the value of the final results obtained, and I would suggest that it is desirable that Mr. Buchanan should illustrate his method of expansion determination so that this can be taken into consideration. The description given in the Paper is quite inadequate to form any idea of the accuracy of the actual test methods adopted.

There are many statements made in the Paper which are open to logical discussion, but no good purpose would be served in this direction until the above is forthcoming.—Yours, etc.,

F. HUDSON.

Glenfield & Kennedy, Limited,
Kilmarnock.
May 28, 1937.

A Cricket Match

INSTITUTE OF BRITISH FOUNDRYMEN *v.* BRITISH WORKS MANAGERS' ASSOCIATION (MIDLAND BRANCH)

The Institute of British Foundrymen, as holders of the Lichfield Trophy, will defend their title in a cricket match against the British Works Managers' Association. By the kind permission of the O.C. Troops, Lichfield, the match will be played on Sunday, July 4, on No. 1 Garrison Ground, Whittington Barracks, Lichfield, commencing at 2.30 p.m. Whittington Barracks is about 3 miles from the centre of the city, along the Tamworth Road, and ample facilities for parking cars are available. Luncheon at 1 p.m. and dinner in the evening will be provided at The George Hotel, Lichfield, for those who desire it. By the kind invitation of several supporters, afternoon tea will be provided on the cricket ground.

The Lichfield Bridgeman Trophy will be presented at the close of the match by Mrs. C. W. Bigg, the wife of the President of the Institute of British Foundrymen. Members who intend being present should write to Mr. J. E. Hurst, Bradley & Foster, Limited, Darlaston Blast Furnaces, Darlaston, for further particulars.

Notes from the Branches

Scottish Branch.—By the kind invitation of the directors of G. & J. Weir, Limited, members of the Scottish Branch will have an opportunity of visiting the Cathcart foundries on Friday, June 4. The foundries have recently been completely reorganised and equipped with modern plant. Members are asked to meet at the works entrance, Newlands Road, at 7.30 p.m.

Random Shots

Readers of a Sunday newspaper were recently asked to name six common habits which have notably diminished since the beginning of the century. The lists sent in contained such suggestions as the decline of letter writing, the decrease of political rancour, and church-going, whilst someone, taking a less serious view of life, misses the old habit of stroking the moustache to induce mentation, practical joking, and the early morning ritual of ironing "The Times." This would make an interesting study in the foundry world. In fact, so much progress has been made since the beginning of the century that it would be difficult to confine one's choice to a mere six. For a beginning one might mention the mixing of stale beer in the sand, the use of solid bottomed cupolas, hand operated jig cranes, not to mention a certain old-fashioned mixture for making castings pressure tight! If one cared to probe into early foundry practice the list would indeed be in danger of savouring of the obscene rather than the obsolete!

* * *

Whilst on the subject of obsolete practices, does anyone still carry out that erstwhile theory of dieting called after a certain Dr. Hay?

* * *

At the opening luncheon of the new foundry at Warrington last week, the Town Clerk added yet another good Scottish story to a collection which must already be large enough to fill any Carnegie Library. A boy was taken from a distressed area in Scotland and placed in work in a foundry in the Midlands. On writing home he said that he liked his work, had comfortable rooms, etc., and that the football team was excellent, considering that there were ten Englishmen in it.

* * *

Here is a true story of an Anglo-Scot, much more Scot than Anglo, who erected in his garden the Scottish standard. His Cockney gardener gazed at it in wonderment for a few minutes before exclaiming "Lumme, guvnor, what sort of a flag do you call that? Is it an Abyssinian flag?"

* * *

One has always been brought up to believe that a shortage in any commodity raises its value, and indeed it is a theory of which the foundry industry is painfully aware at the moment (see pig and scrap iron quotations). This, however, is hard to believe when breakfasting off bacon that has shrunk in the pan, after having just struggled into one's pants shrunk in the wash!

* * *

An American visitor says that the baths in English hotels are much bigger than those in use in America. Does this explain why it costs a shilling to fill one?

* * *

It appears that Marksman's was not the only delicate ear to be offended by the film commentator's word "to coronate," for the "Morning Post" has published some learned and considerable correspondence on the matter. Strictly speaking, such a word does exist, though it seems to be not only medieval but even then was not used in the sense of crowning kings and queens. Perhaps the commentator was so impressed with the medieval character of the ceremony that he just couldn't help himself.

* * *

This week's problems: How many cricket elevens make a score? Do sit down strikers stand up for themselves? Should the slogan "Eat more fruit" end up with "and get the pip"?

"MARKSMAN."

Factors Affecting the Ramming Density of Sand*

By J. DEARDEN, B.Sc., A.M.I.Mech.E.

The ramming density of sand is greatly influenced by the degree of ramming imposed on it, so that loose sand may have its density raised from 1.0 to as much as 1.8 by hard ramming. A measure of the work done in ramming sand is to be found in the number of 2-in. drops to be given by the 14-lb. weight in the standard A.F.A. rammer in order to compress a given weight of sand into a specimen 2 in. high. The figures for three types of sand are shown in Table I.

TABLE I.—*Effect of Ramming on the Density of Three Foundry Sands.*

No. of drops.	Scottish rock sand.	Belfast red sand.	Irvine sea sand.
1	1.53	1.60	—
3	1.65	1.65	1.45
10	1.79	1.75	1.50
20	1.83	1.79	1.525
30	1.85	1.81	1.55
40	1.87	1.82	1.575
50	1.88	1.835	1.60

Effect of Composition

The actual densities of the several constituents which make up the sand, and their concentration, will affect the density regardless of the degree of ramming. The densities of the common constituents of sand are as follow:—

Constituent.	Density.
Sand grains	2.5—2.7
Clay	1.9—2.0
Coal-dust	1.25—1.30
Coke	1.0
Moisture	1.0
Sawdust	0.6—0.8
Manure	—
Iron	7.5

The effect of these constituents depends on whether they displace some of the sand grains, or fill the void spaces between them. Additions of coal-dust, sawdust and manure are lighter than the sand grains they displace, and so decrease the density, while pellets of iron have the reverse effect. Sand of irregular grain size has smaller voids, and rams to a higher density than a sand in which the grains are of equal size. Substances such as silt, clay and moisture tend to fill the voids, and so to increase the density. Practical proofs of these effects are shown in Table II.

This brief survey of the causes of density leads to a consideration of the effect of these factors, acting through the density, on the physical properties of sand.

Effect of Density on the Properties of Sand

It would be ideal if the properties of sand could be measured as it lies rammed in the mould; but as the degree of ramming varies throughout each mould, and between one mould and another, this is impracticable for routine testing, and sand has to be tested in the form of specimens of standard shape and size, and rammed under standard conditions so as to eliminate the greatest of the many variables.

Two standard methods of ramming are in use in this country. As these have been described in previous Papers presented to the Institute, it is sufficient to mention that the one recommended by the British Cast Iron Research Association utilises the principles of ramming to a standard density, while the other, developed by the American Foundrymen's Association, and extensively used in this country, operates on the principle of applying a constant degree of ramming to as much sand as will give a specimen of standard dimensions. In both systems the permeability and compressive strength of the specimen is determined in a similar manner, and the results are expressed in the same units.

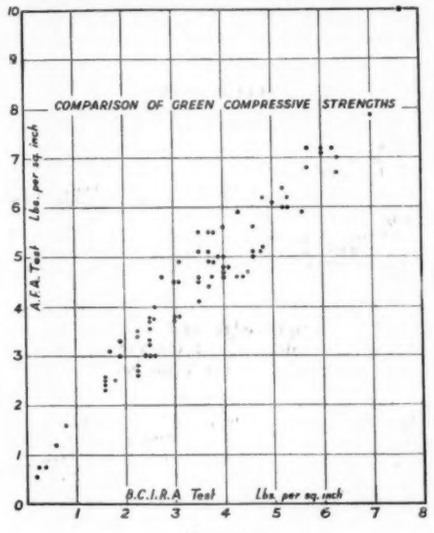


FIG. 1.

The effect of variations in sand composition on the test results obtained in both systems will now be examined. Sands high in moisture, clay, and silt, sands of irregular grain size, and those contaminated with iron pellets have been shown to be naturally high in density. To compress such sands to a standard density, as in the B.C.I.R.A. method, will require less effort than that necessary to compress to the same density, sands of opposite nature, namely, low in moisture, clay, and silt, or of regular grain size, or free from iron pellets. The less effort required to compress the sand, the greater are the voids in the sand, leading to increased permeability and decreased strength. In the A.F.A. method, the effort required to compress the sand is constant, and independent of the amount of moisture, clay, silt, coal-dust, and iron in the sand.

TABLE II.—*Effect of Moisture, Clay and Silt and Coal-Dust on Sands.*

MOISTURE.

Green facing sand.		Mouldsworth red sand.	
Moisture Content. Per cent.	A.F.A. density. 3 drops.	Moisture content. Per cent.	A.F.A. density. 3 drops.
0.0	1.43	0.0	1.50
5.5	1.55	4.5	1.58
9.0	1.75	9.0	1.65
10.6	1.80	—	—

CLAY AND SILT.

Sand.	Moisture. Per cent.	Clay and silt. Per cent.	A.F.A. density. 3 drops.
Sea sand	7.0	7.0	1.45
Scottish rock	5.0	25.0	1.65

COAL-DUST.

Sand.	Moisture. Per cent.	Coal-Dust. Per cent.	A.F.A. density. 3 drops.
Scottish rock	5.0	0.0	1.65
	5.0	10.0	1.50
Lenton Red	5.5	0.0	1.65
	6.5	13.0	1.50
Mouldsworth Red	4.5	0.0	1.58
	5.2	15.0	1.44

The effect of moisture alone is proved by the results shown in Table III obtained from a green facing sand.

It may be admitted that some of the moisture contents used are outside the working range, but it can be shown by interpolation that if the moisture in this sand be raised from 4 to 6 per cent., the permeability increases from 45 to 72 when measured on B.C.I.R.A. specimens rammed to a density of 1.56, and decreases from 69 to 61 in A.F.A. specimens. As moisture can only take its place in the void spaces, it must reduce permeability; and as this effect is revealed by the A.F.A. method of ramming, and not by the B.C.I.R.A. method, the writer is forced to conclude that the A.F.A. method is the correct one.

TABLE III.—*Effect of Moisture on the Properties of a Green Facing Sand.*

B.C.I.R.A. METHOD.

Moisture. Per cent.	Permeability number.	Green strength. Lbs. per sq. in.	Density.
0.0	19	0.0	1.56
5.5	56	4.4	1.56
9.0	180	0.45	1.56
10.6	205	0.3	1.56

A.F.A. METHOD.

Moisture. Per cent.	Permeability number.	Green strength. Lbs. per sq. in.	Density.
0.0	70	0.0	1.43
5.5	65	5.1	1.55
9.0	42	2.8	1.75
10.6	21	2.7	1.80

Effect of Ramming Method on Strength

Increased ramming always brings increased compressive strength, but a higher figure is generally registered with the A.F.A. specimen than with the B.C.I.R.A. specimen rammed to the same density. Fig. 1 shows the extent of this difference over a wide range of sands, and it will be noticed that, in general, the A.F.A. values are about 1 lb. per sq. in. above the corresponding B.C.I.R.A. figures. One reason for this is to be found in the more slender proportions of the B.C.I.R.A. test-piece, but the difference in the ramming methods produces a more vital effect.

When a specimen is rammed from one end only, the density cannot be uniform throughout, and will vary from a maximum next to the rammer, down to a minimum at the further end. The mean density will be found about half-way between the ends, as in the A.F.A. specimen. The B.C.I.R.A. specimen, rammed by the double compression method, will exhibit maximum density at the ends, with a minimum in the middle; and fracture in compression will occur in a region of low density, and therefore of low strength. This appears to account for the low values of strength obtained with this specimen.

The B.C.I.R.A. specimen is said to give a more truly scientific test of the strength of sand by virtue of its height being twice the diameter, thus permitting a fracture of the sand in pure shear. While this cannot be claimed for the relatively squat A.F.A. specimen, the straight-line relation derived from Fig. 1 proves this specimen to be at least equally satisfactory for determining the strength of sand.

Sensitivity of B.C.I.R.A. Method

The B.C.I.R.A. specimen is very sensitive to slight inaccuracies in the weighing of the sand.

(*Concluded on page* 442.)

c2

* Winning entry in a Short Paper Competition organised by the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen.

Nomograms in a Pipe Foundry*

By C. K. DONOHO

The nomogram, or alignment chart, has been the subject of several interesting articles in recent technical literature.[1 2] A useful method for rapid graphical solution of routine calculation, the nomogram is now receiving the attention of engineers and scientists which it has long deserved.

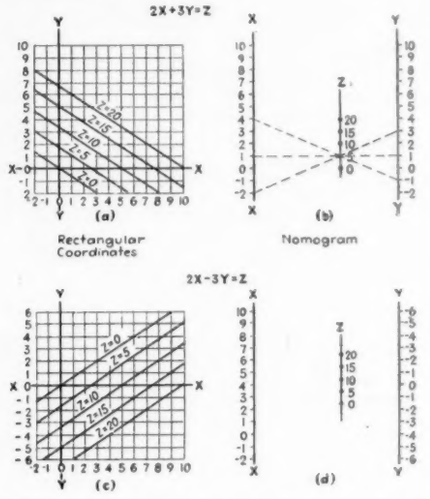


FIG. 1.—EQUATIONS PLOTTED ON NOMOGRAPHIC CO-ORDINATES.

Probably the best use of such a rapid calculating method will be found among the practical men, especially in those cases where, in the rush of production, the foreman or superintendent must occasionally waste a half hour getting out his logarithm tables and slide rule to solve a problem of volume or weight which an unusual order has necessitated. In most foundries, as in other industries, there are continually arising mathematical problems of two or three general types which though easily solvable by arithmetic or algebra, often delay the foreman.

This article attempts to explain simply the general principles of common types of nomograms, and to give a few practical examples which have been found to be of convenience at the foundry in which the author is employed.

Principle of the Nomogram

The cardinal principle of the nomogram is: Any equation whose locus is a straight line when plotted on rectangular co-ordinates, has for its locus a point when plotted on the co-ordinates of the nomogram. (Nomogram, as used here, refers to the simplest type of alignment chart consisting of parallel axes with a centre scale of values sought.)

An example will demonstrate this clearly: In the equation

$$2X + 3Y = Z$$

X and Y are determined and Z is to be calculated. When Z is 0, 5, 10, 15, the loci of the equations thus formed when plotted on rectangular co-ordinates, are a series of parallel straight lines, Fig. 1 (a). Plotted on nomographic co-ordinates, Fig. 1 (b), there is a point corresponding to each linear locus on rectangular co-ordinates. For example, lines connecting all values of X and Y which give Z = 5 cross at one point between the X and Y axes.

It will be seen, Fig. 1 (b), that the point loci of the equations for different values of Z fall on a straight line parallel to the two axes, and in such a position that the distances from the centre Z axis to the X and Y axes are in the ratio of 3 to 2, respectively. The position and graduation of the Z scale are determined by the type of equation and the coefficients of the variables. Formulæ exist for locating and dividing the centre scale in most types of nomograms,[1 2] but it is often simpler to locate the necessary point loci by plotting on a lay-out.

When other desired values of Z are calculated and marked on the centre scale, the simplest type of nomogram is obtained. With X and Y known, to find Z, connect the values of X and Y with a straight edge and read the value of Z on the Z scale. Fig. 1 (c) and (d) show the similar treatment of the equation

$$2X - 3Y = Z$$

When this equation is plotted as a nomogram, Fig. 1 (d), the X and Y scales must ascend in opposite directions, because of the negative sign.

However, the simple linear equations of this type are so easily solved that there is rarely any need for constructing a nomogram for this type of problem. By proper choice of scales and simplification of the equations, many more complex equations become linear on rectangular co-ordinates, and may be set up in the form of a nomogram with equal facility.

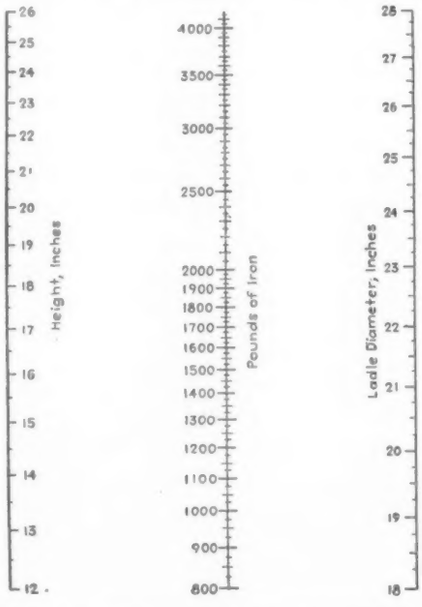


FIG. 3.—NOMOGRAM FOR CALCULATING LADLE CAPACITY.

Equations of the type XY = Z (a special case of the hyperbola), Fig. 2 (a), become linear when lotted on logarithm scales, as the equation then becomes, in effect, Log. X + Log. Y = Log. Z, which is a linear equation. This type of equation may be plotted as a nomogram by the use of logarithm scales for the X and Y axes, and the Z line between will also be a logarithm scale, Fig. 2 (b).

A way of constructing a nomogram for this type of equation without the use of the logarithm scales is to make the X or Y values the middle scale. For example, for any constant value of Y, the equation is linear in X and Z, Fig. 2 (c), and on nomographic axes, all values of X and Z which give a certain value of Y will cross in a point, Fig. 2 (d).

It must be remembered, however, that a nomogram cannot be constructed without the use of logarithm scales with Z as the middle axis,

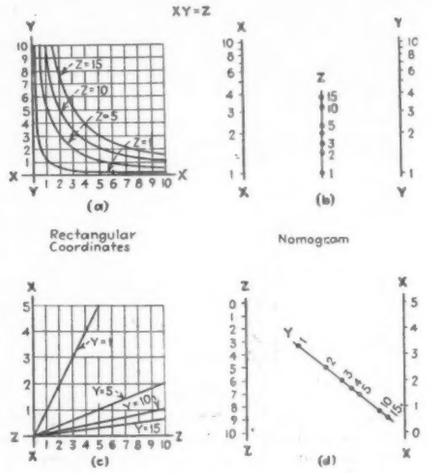


FIG. 2.—A SPECIAL TYPE OF HYPERBOLA.

because with Z constant the equation is not linear in X and Y.

Equations of the type:

$$X = YZ^2 + Z$$

are best handled by making X and Y uniform outside scales and plotting the points for the Z scale in the middle.

An exponential function: $X = Y^z$ becomes linear in X and Y on logarithm scales since:

$$\text{Log. } X = Z \text{ Log. } Y$$

An equation:

$$X = Z^y$$

becomes linear in X and Y when plotted with a logarithm scale for X values and a uniform scale for Y values since: Log. X = Y Log. Z.

A complex equation of the type:

$$2X = Y^2Z + Z^2X + Z$$

becomes linear in X and Y when the X axis is a uniform scale and Y axis is a squared scale.

These particular examples given are by no means meant to be complete but are given in order to illustrate the principle that scales must be so chosen that the equation becomes linear on rectangular co-ordinates, before a nomogram of the type here considered can be constructed. Equations of only three variables are considered here, but by double axes or "box" nomograms equations of four or more variables may be solved by the same general principles.[3 4]

Calculating Weight of Iron in Ladle

At the American Cast Iron Pipe Company it is often necessary to put a certain weight of iron in a ladle. Since the diameters of the ladles vary, not only with different ladles, but also with each new lining, calculations are often required to determine the necessary height in the ladle to give the desired weight of molten iron. While this calculation is not arduous, it was a decided bother to the man on production to stop and calculate a ladle every other day. Also, a costly mistake is very easy to make, as in the rush of production such a calculation may easily go awry.

REFERENCES.

1 Eldon K. Ralston. "How to Construct Nomograms for Use in Design," "Machine Design," February, 1933, p. 33.

2 M. G. Van Voorhis, "How to Make Alignment Charts," "Product Engineering," January, February, March, May, and July, 1936.

3 "Design Work Sheets—New Series." Compiled by "Product Engineering." McGraw Hill Publishing Company, New York.

4 "Strength and Elastic Properties of Cast Iron," by W. J. Schlick and Bernard A. Moore. "Bulletin No. 127 of Iowa Engineering Experiment Station, Iowa State College, p. 29.

* From "Metals and Alloys." The author is metallurgist, American Cast Iron Pipe Company, Birmingham, Ala.

The equation to give the height (inches) in a cylindrical ladle of given diameter (inches) to give a certain weight (pounds) of iron is:

$$\text{Height} = \frac{4 \times \text{Wt}}{\pi\,(\text{Dia})^2 \times 0.26}$$

Where 0.26 is the weight in pounds of a cubic inch of the molten iron used.

Logarithm scales were used to make the equation linear, and the completed nomogram is shown in Fig. 3. Prints of this chart are posted in the shop where needed, and the workman simply measures the diameter of his ladle, and with a straight edge connecting this figure to the desired weight reads the necessary height on the scale for height. It need hardly be said that the use of this nomogram has effected time saving, greater accuracy, and the elimination of costly errors.

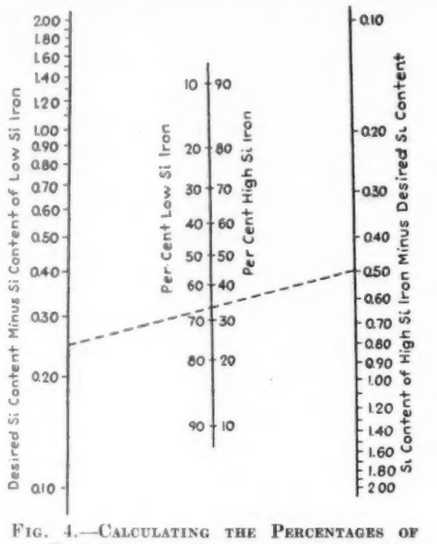
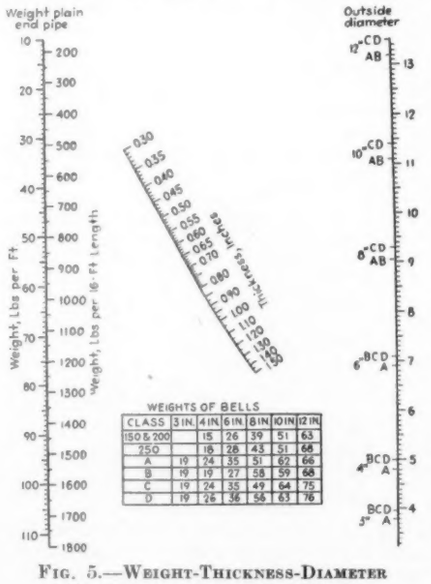

Desired Si Content Minus Si Content of Low Si Iron
Per Cent Low Si Iron
Per Cent High Si Iron
Si Content of High Si Iron Minus Desired Si Content

FIG. 4.—CALCULATING THE PERCENTAGES OF TWO IRONS OF DIFFERENT SILICON CONTENTS TO GIVE A DESIRED SILICON CONTENT IN A THIRD IRON.

Another simple calculation which may be made rapidly on the job by the use of a nomogram is shown in Fig. 4. This chart calculates the percentage of two irons of different silicon contents to be used to give a desired silicon content between the two.

If a mix averaging 1.75 per cent. silicon from scrap is 1.50 per cent. silicon and pig-iron of 2.25 per cent. silicon, then with a straight edge connect 1.75 − 1.50 = 0.25 on the left hand scale to 2.25 − 1.75 = 0.50 on the right hand scale and read on the middle scale: 67 per cent. of the 1.50 per cent. Si scrap and 33 per cent. of the 2.25 per cent. Si pig must be used.



CLASS	3 IN.	4 IN.	6 IN.	8 IN.	10 IN.	12 IN.
150 & 200		15	26	39	51	63
250		18	28	43	51	68
A	19	24	35	51	62	66
B	19	19	27	58	59	68
C	19	24	35	49	64	75
D	19	26	36	56	63	76

FIG. 5.—WEIGHT-THICKNESS-DIAMETER NOMOGRAM FOR CAST-IRON PIPE.

Calculating a Mixture

As another example, suppose it is desired to calculate a mix of 1.80 per cent. silicon using 25 per cent. of a 1.50 per cent. silicon return scrap and two pig irons of 1.75 and 2.25 per cent. silicon. Connect 1.80 − 1.50 = 0.30 on the left hand scale to 25 per cent. on the left side of the centre scale and read on the right hand scale. The reading is 0.10. Therefore, the pig-irons used with the scrap must average 1.80 + 0.10 or 1.90 per cent. silicon. The percentages of the two pig-irons to be used are found, as in the first example, by connecting 1.90 − 1.75 = 0.15 to 2.20 − 1.90 = 0.35 and reading the centre scale. The reading gives approximately 70 per cent. of the low silicon pig-iron and 30 per cent. of the high silicon pig-iron. Therefore, for a mix of 1.80 per cent. silicon, 25 per cent. of 1.50 per cent. silicon scrap is added to a mixture of pig-irons which is 30 per cent. of the 2.25 per cent. silicon pig-iron and 70 per cent. of the 1.75 per cent. silicon pig-iron, or the final mix is:

1.50 per cent. Si scrap, 25 per cent.; 2.25 per cent. Si pig, 22.5 per cent.; and 1.75 per cent. Si pig, 52.5 per cent.

If three pig-irons in addition to the scrap are to be used, by choosing a definite percentage of one, the average silicon content of the other two is determined and finally the percentages of these two are found as before.

This chart is shown mainly to illustrate another general type of problem easily solved by the nomogram. The greatest value of this type of nomogram may be realised by adapting it to some particular problem such as determining the amount of ferro-silicon to be added in the ladle to give a desired rise in silicon, or for determining the amount or percentage of steel to be added to decrease the silicon, etc. Nomograms constructed for the particular recurrent problems peculiar to each shop and for the particular ranges desired are always of greater practical value than the more generally applicable nomograms often published.[3]

To Calculate Weight of Pipe and Thickness

Another nomogram found to be of value is shown in Fig. 5. This chart is used to find either the weight of pipe to give a certain thickness, or the thickness required to give a certain weight for a pipe of given diameter. The equation is:

$$\text{Wt. per ft.} = 9.8t\,(\text{dia.} - t)$$

The equation is linear in weight and diameter for any given thickness, so uniform outside scales were used for weight and diameter and the points on the scale for thickness were calcuated and plotted.

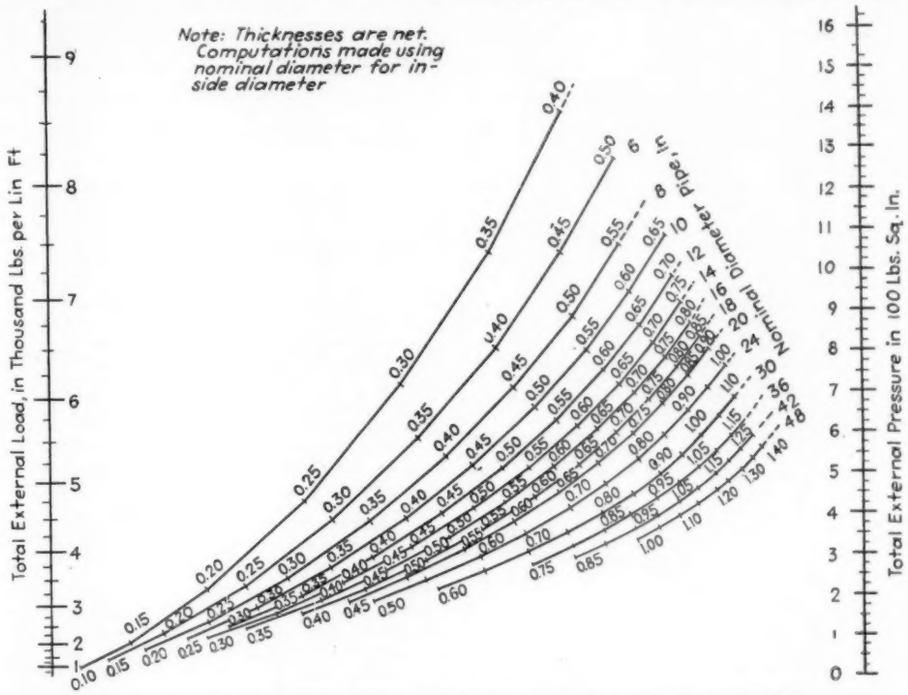

Note: Thicknesses are net. Computations made using nominal diameter for inside diameter
Total External Load, in Thousand Lbs. per Lin. Ft.
Nominal Diameter Pipe, in.
Total External Pressure in 100 Lbs. Sq. In.

FIG. 6.—A LOAD-PRESSURE-THICKNESS NOMOGRAM. S = 11,000; R = 31,000.

The three examples given above illustrate the use of the nomogram for quick solution of relatively simple routine calculations, and this type of chart is of value in proportion to the frequency of its use.

Where Nomogram is a Necessity

There occur occasionally problems which are practically unsolvable except by some graphical method, and in these cases the nomogram is almost a necessity. From the equation developed by Schlick and Moore[4] for strength of cast-iron pipe under combined tension and flexure there may be calculated the following equation relating trench load and internal pressure to the required thickness of cast-iron pipe:*

$$\frac{2\,St}{D} - P = \frac{2\,St}{D}\left(\frac{0.0795\,(D+t)W}{Rt^2}\right)$$

Where: W = External load in lbs. per linear feet.
t = Required thickness of pipe in in.
P = Total internal pressure in lbs. per sq. in.
D = Inside diameter of pipe in in.
R = Modulus of rupture in lbs. per sq. in.
S = Tensile strength in lbs. per sq. in.

* The relation developed empirically by Schlick and Moore[4] from studies of cast-iron pipe for cast iron under tensile and flexural stresses is:

$$S - S_1 = S\left(\frac{R_1}{R}\right)^2$$

Where: S = Ultimate bursting strength.
R = Ultimate crushing strength.
S_1 and R_1 = Tensile and flexural stresses operating together.

In the cast of a pipe in service it is desired to substitute internal pressure for tensile stress and external load for flexural stress. When S is replaced by the value for bursting strength of a pipe $\left(\frac{2St}{D}\right)$ and R is replaced by the value for crushing load of a pipe $\left(\frac{Rt^2}{0.0795\,(D+t)}\right)$ the relation as given above is obtained.

(*Concluded on page 442.*)

Scrap Specifications and Prices

MAXIMUM PRICES FOR STEELWORKS SUPPLIES

Under the scheme for the control of supplies and prices of scrap the British Iron and Steel Federation has classified the various descriptions of scrap material for use in steelworks according to the following specifications, for which maximum prices have been laid down :—

(1) *Heavy steel scrap,* free from wrought iron, alloys and other deleterious materials, and not less than ¼ in. thick, and in works' furnace sizes.

(2) *Heavy wrought and steel scrap,* free from alloys, cast iron and other deleterious materials, not less than ¼ in. thick, but may include properly cut heavy motor-chassis frames in works' furnace sizes.

(3) *Medium wrought-iron and steel scrap,* not less than ¼ in. thick, in works' furnace sizes, including sheared piping and bedsteads cut small to works' specification, to be free from all deleterious materials.

(4) *Hydraulically-compressed new steel and heavy faggoted,* free from coated material, in works' furnace sizes.

(5) *Hydraulically-compressed old wrought iron and steel,* free from terne-coated, tinned, galvanised and enamel and other deleterious materials, in works' furnace sizes.

(6) *Hand-bundled new light steel-sheet cuttings and bale hoops,* free from terne-coated, tinned and other deleterious materials, in works' furnace sizes, and tied with wire.

(7) *Bundled or coiled wire rope,* in works' furnace sizes.

(8) *Old light wrought iron and steel,* suitable for pressing, free from terne-coated, tinned, enamel, galvanised and other deleterious materials.

(9) *Heavy steel turnings,* free from bushy, alloys, and non-ferrous metals.

(10) *Heavy steel turnings not free from alloys,* excluding bushy and non-ferrous material.

(11) *New loose light steel cuttings,* suitable for pressing, free from terne-coated, tinned, galvanised and other deleterious materials.

(12) *Heavy cast-iron scrap,* in works' furnace sizes, free from burnt material, not less than ½ in. thick.

(13) *Light cast iron,* in works' furnace sizes, free from burnt material.

(14) *Cast-iron borings,* free from corroded lumps and dirt.

(15a) *Mixed cast-iron borings and steel turnings,* free from corroded lumps and dirt.

(15b) *Bushy turnings.*

The following table shows the net maximum prices laid down for the fifteen classes of scrap, according to the foregoing classification, in each consuming district :—

Net Maximum Prices per Ton Delivered Consumers' Works for the Various Classes of Steelworks' Scrap.

District.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Scotland	67 0	65 0	60 0	67 0	60 0	60 0	55 0	42 6	52 0	—	55 0	67 0	62 0*	42 6	42 6
North-East Coast	69 0	67 0	62 0	67 0	62 0	62 0	57 0	45 0	55 0	—	57 0	67 0	62 0	42 6	45 0
North-West Coast	72 6	70 0	67 6	72 6	—	67 6	67 6	—	60 0	—	60 0	—	—	—	—
Lancashire	68 0	65 6	61 0	65 6	60 6	60 6	60 6	—	50 0	45 0	—	62 6	57 6	42 6	40 0
Cheshire	—	67 0	—	67 0	—	62 0†	62 0	47 6	55 0	—	55 0	—	—	—	—
Brymbo	—	67 0	62 6	67 0	62 0	62 0	62 0	—	55 0	50 0	—	67 0	—	—	—
Shelton	—	66 9	61 6	66 0	62 0	62 0	62 0	—	55 0	50 0	—	—	—	45 9	—
Sheffield	67 6	65 0	61 0	67 6	62 6	62 6	62 6	42 6	52 6	45 9	57 6	67 6	62 6	42 6	42 6
Lincolnshire	69 9	66 6	62 6	69 0	64 0	64 0	64 0	42 6	54 0	46 6	59 0	—	—	—	—
Midlands	60 0	58 6	56 0	60 0	56 0	56 0	56 0	37 6	—	45 0	47 6	—	62 6	47 6	42 6‡
S. Wales (East)	68 0	65 6	61 6	68 0	61 6	63 0	60 6	45 6	56 0	50 6	55 6	68 0	63 0	43 0	48 0
S. Wales (West)	70 0	67 6	63 6	70 0	63 6	65 0	62 6	47 6	58 0	52 6	57 6	70 0	65 0	45 0	50 0

* Also burnt iron. † Bale hoops, 57s. 6d. ‡ Bushy only.

Quantity Differentials

The Federation recommends that on heavy steel scrap (Class 1), wrought iron and steel scrap (Class 2), and medium steel scrap (Class 3) the maximum price in each district should apply only on contracts fixed at 500 tons and over for each of the three grades, with 1s. per ton less for quantities of 250/500 tons, 2s. less for 100/250 tons, and 2s. 6d. less for less than 100 tons.

For all classes of scrap other than the three mentioned above, the quantity differentials should be as follows :—Not less than 250-ton lots, maximum price; 100/250-ton lots, 1s. per ton less; 50-ton lots, 2s. less; under 50 tons, 2s. 6d. less. It is also recommended that the period of delivery for these contracts should not exceed three months.

As Scotland is a smaller collecting area, it is recommended that the quantities for Nos. 1, 2 and 3 should be as follow :—500 tons and over, maximum price; 250/500 tons, 1s. per ton less; 50/250 tons, 2s. less; under 50 tons, 2s. 6d. less. For all classes of scrap other than the three mentioned above the differentials are to be the same as for England.

For scrap delivered coastwise, it is recommended that the price to the end of 1937 should be 3s. per ton, c.i.f., less than the maximum delivered price for the district.

Factors Affecting the Ramming Density of Sand

(*Concluded from page* 439.)

Likewise, an error of a few thousandths of an inch in the diameter of the compression tube has a marked effect on the degree of ramming, and therefore on the properties of the resulting specimens. An error of 1 per cent. in weighing the sand can be magnified to 14 per cent. in the permeability, and to 7.5 per cent. in the strength of a B.C.I.R.A. specimen. A similar weighing error of 1 per cent. will affect the height of an A.F.A. specimen by 1 per cent., and the permeability will vary inversely to an equal degree, while the effect on the strength will be negligible, because the degree of ramming is independent of errors in weighing the sand.

Suggested Measure of Sand Quality

The testing of sand at various densities is not confined to the B.C.I.R.A. method, as by taking different weights of sand and adjusting the number of drops of the ramming weight necessary to compress the sand to the standard 2 in. specimen, a range of densities may be tested by the A.F.A. method, with the advantage that the number of drops give a measure of the work necessary to achieve any given density and strength.

While testing various sands over a range of densities in this way, the writer has noticed that the product of the permeability and the green strength is very nearly a constant for each sand, and he suggests the use of this constant as a single measure of sand quality. Green facing sands usually lie between 100 and 300, while the strong and open steel moulding sands rise as high as 1,000 and 2,000. Close sands, lacking in bond, may be as low as 50. The constant is very sensitive to moisture content, as an increase in this decreases both permeability and green strength together, thus lowering the value of the constant by a marked degree.

Every pattern requires the sand ramming round it to some minimum strength for the successful moulding and pouring of the casting. By dividing this value of the strength into the constants of the available sands, the founder would know the approximate permeabilities of these sands as rammed into the mould, and would thus be able to choose the ideal sand for his work.

New Tantalum and Tungsten Deposits

News of metals, both of which are of considerable importance to the iron and steel industry, has come to hand during the past week. From the Northern Territory of Australia it is reported that deposits of tantalum, which is used chiefly as an alloying material in the manufacture of special iron and steels, has been located.

The second metal to which prominence has recently been given is tungsten. It is understood that operations have commenced on a new tungsten mine on Hemerdon Ball hill, on the south-western edge of Dartmoor. The "Morning Post" reports that between 60 and 70 men are at present at work, and a complete experimental plant is being installed. It is pointed out, however, that until the productivity of the ore has been exhaustively tested, future developments cannot be estimated. The Hemerdon wolfram is stated to have been found in association with china clay. Approximately 200 tons a year of wolfram are already being produced from Castle-an-Dinas, on Bodmin Moor, Cornwall. Attention was first directed to the practical possibilities of the West Country when tin-mine tips in Cornwall were worked for the "waste" tungsten which they contained.

Nomograms in a Pipe Foundry

(*Concluded from page* 441.)

For a given size and kind of pipe D, R, and S are constant, and when cleared the equation becomes:

$$(2\,R^2SD)t^4 - (R^2D)\,P t^3 - (0.01264\,S)\,W^2t^2 - (0.02528SD)\,W^2t - (0.01264\,SD^2)\,W^2 = 0.$$

This equation becomes linear in W and P when the P scale is a uniform scale and the W scale a squared scale since P occurs only as the first power and W only as the second power.

The t scale for a given size and kind of pipe may be plotted by determining the ultimate value of P necessary to cause failure when W = 0, and the ultimate value of W necessary to cause failure when P = 0 from the relatively simple formulæ:

$$P\,(Ult) = \frac{2\,St}{D}$$

$$W\,(Ult) = \frac{Rt^2}{0.0795\,(D + t)}$$

A nomogram so calculated is shown in Fig. 6. By connecting with a straight edge the total external load and the total internal pressure on the outer scales, the thickness of pipe which will just fail under these conditions may be read on the inner scales for each size of pipe. This equation is extremely difficult to solve for any other than a graphical method, yet thousands of readings on the nomogram were made in recent work on specifications for cast-iron pipe.

The examples of nomograms shown are those which have been used and found to be of practical value, and it is hoped that they may suggest similar applications for the use of other foundries.

A Compact Conveyor System

Floor space was at a premium in a medium size grey iron production foundry in New York State, where thousands of electric refrigerator castings were in great demand. Mould storage, full or empty, presented a problem. Of several possible solutions, the handling system shown in Fig. 1 presented the most advantages from the standpoint of a complete utilisation of the continuous flow principle, with all mould storage on the conveyors continuously. The compact design concentrates large production facilities within very small space, and the use of roller type conveyors made the resulting installation cost but a fraction of other proposed designs.

From each of two moulding machines, with capacities of one mould per minute, the filled moulds are delivered over an alligator switch to any one of four parallel level storage lines of roller conveyors. As each storage line is filled, the boxes are gradually worked down to the pouring zone at the opposite end of the lines, where pouring ladles are suspended from an overhead crane. After pouring, the moulds are taken through another alligator switch to a single line of roller conveyor which feeds the low end of a travelling booster. This booster is a power driven steel apron conveyor mounted on wheels running on tracks, and delivering at the high end to any one of the four lines of cooling conveyors running back through the middle of the room to the knock-outs, situated between the two moulding machines. These cooling lines have just enough down grade to permit the moulds to move by gravity towards the knock-out. At the knock-out the sand passes through vibrating screens to the sand reclaiming system below, while the castings are transferred to an apron conveyor leading to the cleaning department. Empty boxes are returned on gravity conveyors to the moulding stations.

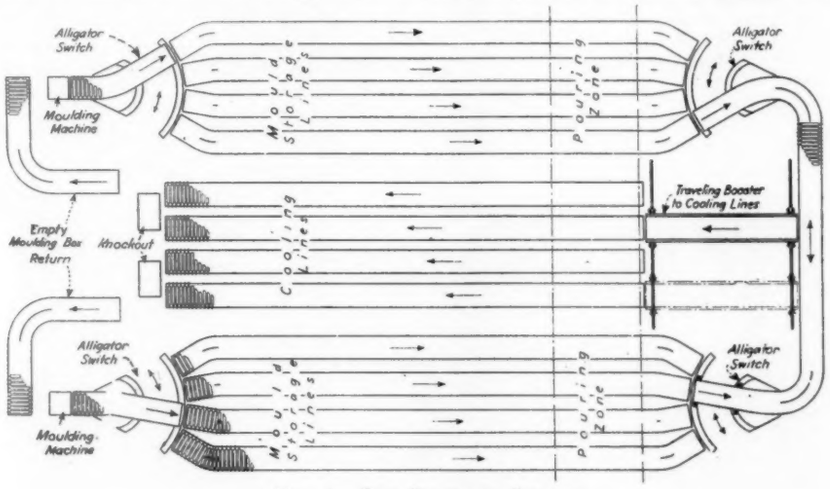


FIG. 1.—THE CONVEYOR SYSTEM.

A special feature of the alligator type switch is the fact that it automatically maintains all rolls in radial position at all times, thus eliminating the objectionable gap which occurs at the pivot end of the ordinary switch.

This conveyor system was designed, built and installed by the Logan Company, Louisville, Ky., and was described in an amplified form by the "Iron Age."

MR. H. A. DAVIES, managing director of the Patent Shaft & Axletree Company, Limited, Wednesbury, has received a presentation from the staff and workpeople.

Book Review

Bearing Metals and Alloys. By Henry Norman Bassett, with a foreword by Sir Henry Fowler. Published by Edward Arnold & Company, 41 and 43, Maddox Street, London, W.1. Price 25s. net.

An authoritative and up-to-date book on this subject has been badly wanted by metallurgists and engineers for some time. Mr. Bassett's book fills the gap in an entirely satisfactory manner. The first part of the book deals with the history of bearing metals, followed by a general discussion of the lubrication of bearings. A clear and simple account is next given of the crystal structure of metals and alloys. This section also contains a brief account of the various theories relating to bearing metals.

The main body of the book consists in a detailed description of different alloys used for this purpose. The effect of a wide range of different impurities on both the lead-base and the tin-base white antifriction alloys is given. The use of copper alloys as bearing metals is discussed in considerable detail. In this section, gunmetals, lead bronzes and phosphor bronzes are included; the same procedure has been adopted as for the white antifriction metals, the effect of different impurities being considered in detail. The final chapter covers the properties and uses of miscellaneous bearing metals such as cadmium-base alloys, zinc-base alloys, metals impregnated with graphite, etc.

Two extremely useful appendices are found at the end of the book. The first is on the polishing and etching of bearing metals; this contains many useful hints on the admittedly difficult task of polishing the softer alloys. The second contains a table specifying the most suitable bearing metals for forty-nine different types of duty. The author is to be congratulated on the insertion of references in the actual text. This is undoubtedly a practice which facilitates the following up of any point in which the reader may be interested. The book is clearly printed and the reproduction of numerous photomicrographs has been well done. This is a book which can be confidently recommended to all engineers and metallurgists. E. W. C.

London Iron and Steel Exchange

Prof. Henry Clay, Economic Adviser to the Bank of England, who will be the speaker at the annual luncheon of the London Iron and Steel Exchange at the Hotel Victoria, Northumberland Avenue, W.C.2, on Tuesday, June 8, will discuss some aspects of fluctuations in trade. Mr. C. Bruce Gardner, chairman of the Exchange, will preside, and a number of well-known members of the iron and steel trades will be present.

"Corecoat"

A new type of mould and core dressing material—of a proprietary nature—has been developed and placed upon the market by Foundry Services, Limited, 285, Long Acre, Nechells, Birmingham, under the trade name of "Corecoat." Its application is at the moment limited to the usual non-ferrous alloys, but work is being undertaken to extend its use to grey iron practice. It is available as a powder to be mixed with water and after drying it forms a porous coating having the appearance of an enamel.

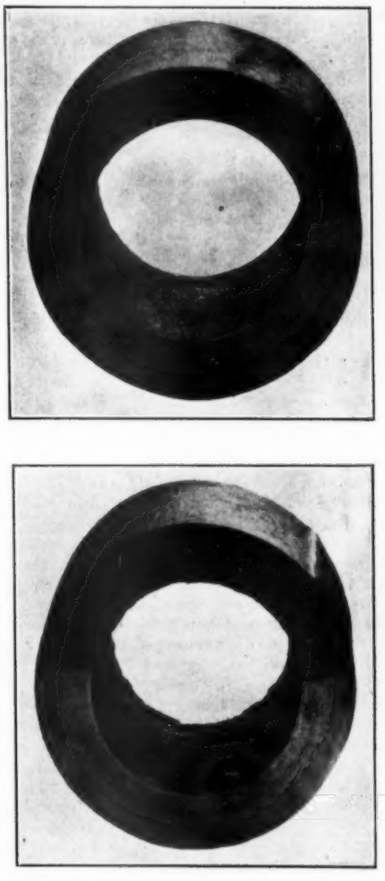


FIG. 1.

Its effect is shown in Fig. 1, which illustrates a phosphor bronze tube. The upper one has been treated with new material, whilst that shown below with the ordinary mould dressing used in the foundry where the test was carried out. Both samples were otherwise cast under exactly the same conditions.

Catalogue Received

Grit Pumps. We believe that the average founder is more interested in making pumps than their installation, but there may be some managers whose duties include the care of machinery handling sludge, which may be in the form of liquid frit for enamelling. If this be the case, they will be doubly interested in a new fourteen-page publication issued by International Combustion, Limited, of Aldwych House, Aldwych, London, W.C.2, as much technical data of both manufacture and performance are given. The type dealt with is the Vac seal, which incorporates a system of rubber linings for the wearing parts.

The Importance of Models

By A. BURGESS

The skill and accuracy required by all concerned in making castings for model engineers is obvious, and it will be readily agreed that makers of engineering models require the best foundry technique applied to their castings. The plant which the author operates consists of what might be termed "ordinary jobbing work tackle" on a miniature scale, including as a necessity provision for the manufacture of all non-ferrous alloys as well as cast iron.

The firm has a "Pneulec" cupola of about 15 cwts. per hr. capacity, an oil-fired crucible furnace capable of melting gunmetal at the rate of 80 lbs. per hr.; a small sand mixer; hand press moulding machines; hand ram pattern stripping machines, and jolt-squeeze stripping machines for the more repetitive class of work. A very useful battery of compressed-air guns are laid on to each moulder. Fig. 1 shows a view of this foundry.

Sand for Small Iron Castings

A considerable amount of comment has been made during the last few years about sand control, and has included the manufacture of synthetic sands, the reconditioning of sands, and the removal of silt from sands. In the manufacture of small castings, silt or fines are as essential as the sand itself in producing the desired finish.

To a finely milled Mansfield sand the silt is introduced in the form of super fine coal dust, finely ground clay, and dusting materials used in the making of the mould. This intermixes with the sand grains and makes the resultant mould face much closer, by preventing the penetration of the molten metal from making what would appear to be a sandpaper-like surface.

If, for example, a customer required a casting of a lathe bed, 6 in. long and 1½ in. high, taken from a scale of ½ in. to a foot, and a mark occurred about ½ in. long, it would reflect on the model as a scab 2 in. long on the full sized work. A model casting, therefore, has to have a skin that coincides with the scale size from which the model is taken.

The following facing sand mixture for cast iron gives quite good results:—Two parts Mansfield red sand; eight parts floor sand; one part super fine coal dust; milled from 10 to 15 min.

Castings requiring to take a very fine impression could with advantage have ¼ part powdered clay added during milling.

Core Sands

The sand used for making cores has to be as permeable as possible, without being unduly coarse, and for this reason, unlike the moulding sand, requires to be free from silt. A minimum fine silica sand washed from all impurities is to be desired. The sand should be thoroughly dried before mixing, as this gives a more constant dry strength to the cores with a given quantity of oil. Various bonding oils have been tried, some with success, others being totally useless.

A good green bond is very necessary as the core boxes are made, in many cases, to at least one hundredth part of an inch, and to maintain the shape without impairing the venting properties of the core by such methods as adding red sand, resin, etc., or milling with semi solids, called for some investigation. A very good core cream as thick as would conveniently mix in a screw type mixer gave the best results.

It is not intended to furnish any figures regarding these tests, but, speaking generally, cheaper oils have to be added in greater quantity to give the core the required dried strength, with a consequent reduction of permeability.

Should a core offer any resistance to the exit of the generated gases and a blowhole occurs, the thin section of the metal prevents any recovery which is often possible in larger work, and in many cases artificial venting has to be resorted to, although this is reduced to a minimum.

Wiring the cores to reinforce them against the action of the metal has, with intricate work, to be done most carefully, and only specially trained men can acquire the touch. Small pins and wire as fine as twenty-six gauge are used. Perhaps readers may think this unnecessary, but imagine a water jacketed cylinder with a bore of 1⅛ in. dia., the section of the water cavity being $\frac{3}{32}$ in. thick, and the length of the cylinder 4 in. with inlet and outlet port cores, and the familiar steam engine cylinder with S-shaped ports leading from the slide face to the cylinder ends, with a section of $\frac{5}{8}$ in. by $\frac{3}{32}$ in. in the ports. These very thin cores have to withstand the wash of metal at very high temperatures, and great care must be taken to make them as strong as possible.

Moulding Methods

Moulding can be classed in three sections, loose pattern, ridge, and plate moulding. Repetition work is, of course, mounted on plates, with gunmetal patterns, which embody the necessary runners, spinners, dirt traps, and vents from core prints, and are moulded in snap flasks on press machines, or jolt rammed in interchangeable steel boxes. With some types of steel boxes a constant check should be made on the pin location, but a fault to which makers should give more attention is the uneven wearing of the box joints.

Boxes often wear hollow from the corners, with the result that when the bottom part of the mould is strickled off and placed on a flat plate or board, it rests on the corners of the box, and leaves a cavity between the sand and the board. The same thing happens with the top part in so far as the weight plate touches the box and not the sand. When the castings occupy a large area of the box joint, the sand in the box (when the mould is being poured) is pressed down to the board and up to the plate, thus making an oversized casting with an excess of flash which, if not scrapped, is very unsightly, and adds to the cost of dressing. Periodically, therefore, when overhauling equipment, those boxes suffering from this defect should be surface ground or machined.

When metal patterns are in use constantly throughout the day, the sand is apt to adhere to them. This is overcome by the use of small paraffin oil sprays worked from the compressed air system, together with strict control of the moisture content of the sand. The paraffin also has the effect of maintaining the mould in a moist condition until the top part can be placed upon it.

Ridge Moulding

Ridge moulding plays a very important part, and, where possible, all patterns of an intricate design are mounted on ridges with good guide pins attached to ensure a clean draw from the mould.

The main reason for ridging is the advantage of the guide pins, and care should be taken to see that these are slightly longer than the longest draft of the patterns, and that they are parallel with it. In many cases ten, twenty, or even more patterns are mounted on one ridge.

The size and section of the ridge should be such as will feed each casting attached to it without allowing any dirt or slag to enter. It is therefore an advantage to have several sizes of ridge patterns, and a number of various sizes in stock for immediate use. These should be cast in brass. Brass pins are fastened into the patterns at the position it is thought best to run the casting, bearing in mind the lay-out of the completed ridge in relation to the size of box to be used.

A box is then filled with sand and the patterns and the ridge are carefully set in position. By means of the brass pins, the patterns are soldered to the ridge, and the solder is afterwards filed into the shape of the in-gate that is desired. When the patterns are such that jointing is complicated, a plaster odd side is cast before production is commenced. Loose patterns, however, cannot be avoided. A point often forgotten in producing a good finish on a casting is to have a top part as shallow as possible, obviating any undue pressure on the mould face.

FIG. 1.—A VIEW OF A FOUNDRY WHERE MODELS ARE MADE.

Customers' requirements are at times far reaching, and as most of them are of the inventive disposition, they desire to make the patterns themselves. It is therefore essential to run an information bureau advising, where necessary, on pattern design, as this saves much time in the foundry.

Non-Ferrous Castings

The non-ferrous section of the foundry offers a great number of difficulties. Arranging the work in order that castings of thick section are not mixed with thinner sectioned ones is extremely important, and work must be arranged so that, when a pot of gunmetal or manganese bronze is wanted, there are enough moulds of castable section to be poured. It is, for instance, useless having thirty moulds with two pouring holes for the same crucible, as it would be impossible to cast them without mis-runs, owing to the metal cooling in the pot.

The facing sand used for all non-ferrous work is well milled Mansfield sand. For brasses and bronzes good ramming is necessary, and a dusting of finely ground pea flour from a closely woven bag assists in making a better casting finish. Ordinary wheat flour requires a dust bag of a more open texture.

Light Alloys

Sand should always be rammed in proportion to the specific gravity of the metal to be cast therein, and therefore for light alloys lighter ramming is required. Incorrect ramming is very

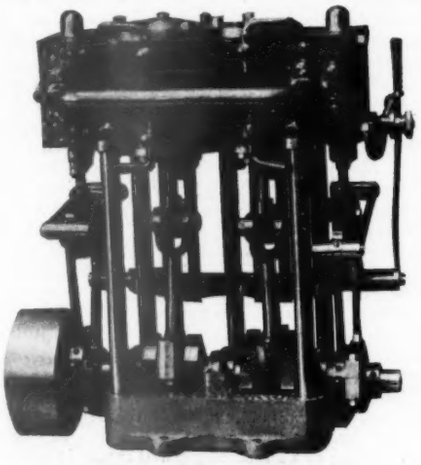


FIG. 2.—A LAUNCH ENGINE.

noticeable on flat surfaces, for the sand expands when the metal enters the mould, and, if it is rammed too hard, buckles are much more liable to occur when light metals are used than if heavier metal were resting upon it. Adequate feeding and well designed runners with chills where necessary are all important factors.

Before closing, the moulds are dusted with french chalk. This should not be left on in any quantity, but should be lightly blown off or markings on the casting will result.

Small Cupolas

Details of small cupolas are seldom published, but a few of the general principles can safely be followed. The tuyere area should be one-

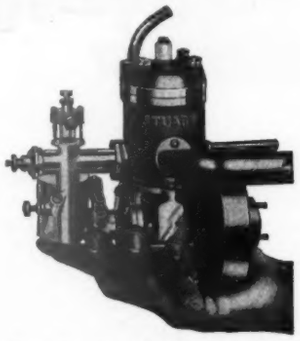


FIG. 3.—THE PETROL "LIGHTWEIGHT" ENGINE.

fifth of the area of the melting zone, the blast required being 5 to 6 in. water gauge; this is quite sufficient on cupolas from 15 to 18 in. dia. The bed charge should be 20 in. above the tuyeres, and the coke used should be about 4 in. cube.

A simple way to estimate the weight of a charge is to weigh out a layer of coke equivalent to the diameter of the cupola and 5 in. deep. This can safely be the coke charge. By multiplying this by 9 or 10, according to the temperature of metal required, the weight of iron per charge may be obtained. This will be found to give approximately 22 lbs. of coke to 2 cwts. of iron, which is within a reasonable ratio. Limestone additions should be of the order of 5 lbs. per charge.

Pig-irons used for such light work are usually of a silky fracture, carrying an analysis of T.C, 3.45; Si, 4; Mn, 1.0; S, 0.2; and P, 1.4 per cent. It is useless, therefore, to add anything but light scrap with a similar analysis, unless metallurgical supervision is made to ensure the softness in the very thin sections, which so readily become unmachinable.

Even with these precautions, the smallest work has to be heated to a dull red heat and cooled off slowly before leaving the shop, to overcome the chilling action of the mould.

Cleaning Model Castings

The fettling department calls for a little more care than the ordinary dressing shop, as breakages easily occur. Intricate filing, and much hack saw work has to be done. The castings that will withstand tumbling in the barrel are placed in with very small scrap; pieces of waste leather are also added to take up the concussion, and as a final polishing agent, rough cardboard or packing paper is placed in with them for several minutes to give a really bright surface to the castings. These methods of cleaning seem old fashioned, but they give good results, and the time taken is well spent. The size of barrel should not exceed 15 in. dia, as non-ferrous work is seriously affected by over-rumbling. Increases in capacity should be made longitudinally only.

Some Typical Models

Fig. 2 shows a launch engine with cast-iron cylinders, the main dimensions of which are: height 5½ in. and length 5¼ in., and it weighs 4 lbs. A three-port, two-stroke, 3 b.h.p. at 3,600 r.p.m. petrol engine is shown in Fig. 3. The length of this model is 5½ in., the height 7½ in., and the weight 34 lbs. 12 ozs.

The author wishes to express his thanks to Stuart Turner, Limited, of Henley-on-Thames, for permission to publish this Paper, and for the loan of the printing blocks.

How Apprentices are Rated in America

BY J. C. LUMSDEN.

Apprentices are rated in the United States, and from information supplied by Mr. W. E. George, industrial engineer of American Steel Foundries, Chicago, it would appear that British firms would do well to emulate such a scheme. One might ask how apprentices can be rated, how the patternshop foreman can compare one with another, or how he knows that his best boy rates as high as the best apprentice in the machine shop.

The rating scale shown in Table I serves to answer these questions. It lists twelve traits by which to judge an apprentice; it could contain many others, but these twelve may be considered essential qualities. If a foreman were asked to grade a boy on his ability to learn, he would probably be unable to answer, but if he were asked to describe that ability as quick, fair or slow, he would give an opinion at once. Similarly, each of the twelve points can be described. If the foreman has a list of the qualities before him and the descriptive words are printed opposite each one, he can, in five minutes, give a sound, unbiased opinion of each apprentice in his department. A check list simplifies the grading

TABLE I.—*Apprentice Rating Scale.*

Date..... Name of Employee .....

Rated by ..... Type ..... Department .....

In the proper places provided below, check (—) employee on the items listed to assist us in grading.

Traits.	Description.	Points.
1. Ability to learn ..	Quick (4); Fair (2) Slow (0)	—
2. Dexterity	Remarkable (4); High (3); Fair (1); Slight (0)	—
3. Capacity for work ..	Unusual (4); Industrious (3); Average (3); Lazy (0)	—
4. Judgment	Uncanny (4); Sound (3); Average (1); Poor (0)	—
5. Initiative	Exceptional (4); High (3); Fair (2); None (0)	—
6. Desire to make good ..	Pronounced (3); Noticeable (2) Low (0)	—
7. Ability to take orders ..	Outstanding (3); High (2); Average (1); Low (0)	—
8. Personal habits	Satisfactory (3); below Par (1); Dangerous (0)	—
9. Company loyalty ..	High (3); Good (2); Fair (1); Lacking (0)	—
10. Perseverance	Unlimited (3); Ample (2); Moderate (1); Weak (0)	—
11. State of health	Excellent (2); Sound (1); Poor (0)	—
12. Ability to mix	Natural (2); Fairly good (1); Doubtful (0)	—
	Total	—

problem, breaks down the prejudices, and crystallises his opinion.

If a comparison between two apprentices is wanted, their check lists must be translated into numerical values (Table II). Take the first five traits in the list, and it will be agreed that

TABLE II.—*Equivalent Rating Scale.*

Pts.	Per cent.	Pts.	Per cent.	Pts.	Per cent.
39	100	26	78	13	39
38	99	25	75	12	36
37	98	24	72	11	33
36	97	23	69	10	30
35	96	22	66	9	27
34	95	21	63	8	24
33	94	20	60	7	21
32	92	19	57	6	18
31	88	18	54	5	15
30	86	17	51	4	12
29	84	16	48	3	9
28	82	15	45	2	6
27	80	14	42	1	3

Signed .....

they are of equal importance. To each then is assigned four points. To the next five traits three points each are assigned, and two points each are allowed to the last two on the list. This totals 39 points for a perfect rating.

The management may want each apprentice's rating expressed in percentages, and it is easy to

(*Concluded from next column.*)

devise a subsidiary scale, set on a studied but non-mathematical basis, that gives the percentages demanded (Table II).

The supervisor of apprentices keeps the record of each apprentice. The monthly grading job sustains the foreman's interest, records his opinions, and shows how much progress the boy is making.

(*Concluded in previous column.*)

D

A NEW CLUB for their employees and their wives is to be opened this month by Blackstone & Company, Limited, of Stamford. The club stands on the site of the firm's former offices at the entrance to the works.

Importance of Temperature Control in Vitreous Enamelling*

TYPES OF APPARATUS USED

By H. ASTBURY, M.I.Mech.E.

The particular requirements of the vitreous enameller can only be expounded by one who has devoted many years to its special problems. The author cannot claim any such qualification, and he proposes, therefore, to state the objects of the vitreous enameller as they appear to him, and to draw attention to the various ways in which temperature control is of importance.

The prime object of the vitreous enameller is to apply a covering or coating to metal objects to give the pleasing appearance of porcelain or pottery with the lightness and strength of metal. This coating must be continuous, so that no liquids or vapours can reach the underlying metal, as this would lead to corrosion and the production of undesirable compounds, and must provide a suitably resistant surface in culinary and chemical appliances. The metal base is usually iron, which is very liable to rust or corrode, and it is obvious, therefore, that the enamel coating must be capable of adhering to the iron, practically uniting with it and expanding and contracting with it over the range of temperature to which it is likely to be subjected in practice. This is one of the points where the effect of temperature must have harassed the early enamellers very considerably until a suitable enamel was evolved. The complete process of manufacturing enamelware resolves itself into the fabrication of the metal base into the shape of the object required and the preparation of its surface to receive the enamel; the preparation of a suitable enamel and its application and fixation to the surface of the metal base. How temperature control affects these various stages of the process will now be considered.

FIG. 1.—MERCURY THERMOMETER.

FIG. 2.—INDICATING THERMOMETER.

FIG. 3.—THERMO-COUPLE.

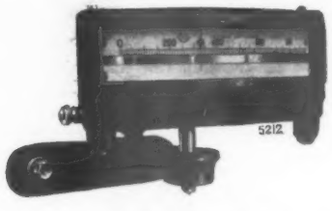


FIG. 4.—MILLIVOLTMETER.

Metal Work

Lighter articles are usually made from sheet steel, stamped and pressed to shape, and the component parts riveted or welded together. If stamping or pressing is done hot, the work will be done more efficiently if the furnace in which the parts are heated is maintained at the correct temperature. Afterwards the finished parts should be annealed or normalised to remove strain, and here it is of great importance to work to the correct temperature so that the internal structure of the steel may be maintained in the correct condition. Following this they are usually pickled in acid to remove scale and then washed, the last traces of acid being neutralised by weak caustic soda or borax. The pickling will be more rapid when hydrochloric acid is used, if the bath is heated, and in the case of sulphuric acid the solution must of necessity be worked at an elevated temperature (usually 150 to 170 deg. Fah.), since the action almost ceases at normal room temperatures. Washing in hot water will ensure rapid drying.

Larger articles are made of cast iron, and in modern foundries pouring temperatures are controlled to ensure sound castings, which are usually annealed and then cleaned by shot-blasting. The articles are now ready for the application of the enamel.

Preparation, Application and Firing of Enamel

The enamel coating consists essentially of complex boro-silicates, together with fluorides which act as fluxes. Various oxides give the desired colours. The ingredients are mixed and fired in a kiln at a high temperature—about 1,200 deg. C.—which should be carefully maintained to ensure good results in the finished enamelware. Underfiring will result in unburnt particles being present, which will affect the finish, whilst overburnt enamels give a poor surface. The contents of the kiln are granulated by quenching in water; the resultant frit is then treated either for the dusting-on process or for use by the "wet-cast" method. In the first case, the dried frit is mixed with the requisite quantity of opacifiers (usually tin oxide) and ground to a fine powder ready for application to the metal surfaces. For the wet-cast process the frit is put into a ball mill, the desired additions of opacifier and clay are added, followed by a suitable quantity of water. The whole mass is then ground down to a predetermined consistency. This enamel suspension is then applied by a spraying process to give a continuous layer of the desired thickness. The articles are then dried and are ready for firing. The drying temperature naturally affects the time taken and the surface finish, and should be kept under control.

When the coating is thoroughly dried the articles are fired in a muffle to finish the process, and the importance of temperature control at this stage is universally recognised, as either overheating or underheating will result in serious blemishes. The enamel may be applied in the dry powder state to heavy cast-iron articles. These are heated up to 850 or 900 deg. C., and then withdrawn from the furnace for the powder to be dusted on, after which the article is returned to the furnace. This process may have to be repeated two or three times to ensure a thoroughly even coating of enamel.

Temperature Control

It will be seen that temperature control is important at almost every stage of this process and the temperatures to be encountered are of the following orders:—

Casting	1,400 deg. C.
Frit making	1,200 deg. C.
Annealing	800 to 900 deg. C.

Firing:—

(1) *Sheet enamel practice*:
- (*a*) Ground coat ... 860 to 900 deg. C.
- (*b*) Cover coat ... 800 to 850 deg. C.

(2) *Wet-cast process*:
Usually the ground coat is omitted as a separate entity, one coat is applied, dried, and then the second coat or "mottling" sprayed directly upon the dry enamel and both coats fired at the same time. Temperatures, in the light stove trade range from 720 to 760 deg. C., generally around 740 deg. C.

Drying:
Up to 230 deg. C. for sheet-iron articles, but for cast iron about 60 deg. C. to prevent surface defects.

Pickling and washing. About 60 to 90 deg. C.

* A Paper read before the Midland Section of The Institute of Vitreous Enamellers.

Thermometers

For the lower temperatures—drying, pickling, etc.—the ordinary mercury-in-glass thermometer can be used with the glass stem protected. More robust instruments, also employing mercury or some other liquid, are dial thermometers (Fig. 1). In these instruments the system is completely filled with liquid and the rise in temperature causes a rise in pressure, due to the expansion of the liquid in a closed space and temperature is measured as a function of the pressure. The indicating system is a pressure gauge movement

FIG. 5.—CONTINUOUS TEMPERATURE RECORDER.

specially designed for the purpose. An important feature of this class of instrument is that they can be used to record the temperatures on a chart as well as to indicate them (Fig. 2).

Thermo-Electric Pyrometers

For the temperatures from 500 or 600 to 1,200 deg. C. or even higher the thermo-electric pyrometer is most useful. The temperature is measured by inserting in the furnace what is known as a thermo-couple. This consists of two wires of different metals, welded together at one end. It is found that if the welded end is heated a difference in electrical potential is set up between the other two ends and suitable metals are chosen so that this electrical pressure increases regularly with the temperature. In practice, a millivoltmeter is connected across these open ends, calibrated directly in temperature, so that this is read off directly on the millivoltmeter. The temperature indicated is the difference between the welded ends and the open ends of the wires. For convenience the thermo-couple is made of a suitable length to insert into the furnace and protected by sheaths against direct action of the hot gases, which usually have deleterious action on the metals of which the couple is made (Fig. 3). From the outer head of the couple, wires having similar thermo-electric action are led to the millivoltmeter, or indicator (Fig. 4), and instead of setting the pointer at zero it is set at the local temperature.

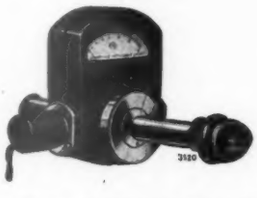


FIG. 7.—DISAPPEARING FILAMENT PYROMETER.

The thermo-couple produces a very low electrical pressure or voltage; about 50 millivolts per 1,000 deg. C. is the highest available from common metals, while the platinum/platinum-rhodium couple only gives about 10 millivolts per 1,000 deg. C. The latter is, however, more suitable for high temperatures—say up to 1,200 deg. C. for continuous work and up to 1,400 or 1,500 deg. C. occasionally. It will be realised that the pointer of the millivoltmeter has insufficient power to move a pen over a chart. If a record is required, therefore, one has to use another method.

Generally the pointer is left free to follow the temperature and moves over the chart on to which it is depressed periodically by a bar operated through the clock driving the recorder. An inked thread is interposed between the pointer and the chart, so this is able to record the exact temperature. Generally, the pointer is depressed every minute, and this gives practically a continuous record as temperatures are not likely to vary very much during that interval on a furnace (Fig. 5). This type of pyrometer is especially suitable for temperatures between 500 and 1,200 deg. C., *i.e.*, for enamelling and annealing furnaces.

Radiation and Optical Pyrometers

For temperatures higher than these it is advisable not to expose any part of the pyrometer to the full action of the heat in the furnace and the radiation or optical pyrometer is most suitable. In the radiation pyrometer the radiant heat is received on a concave mirror and brought to a focus where a small thermo-couple is placed to receive it. The temperature at the focus bears a direct relation to that in the furnace and so the temperature is measured without exposing the couple to its destructive effects. An indicator or recorder similar to that used with thermo-electric pyrometers (Figs. 4 and 5) may be used. The concave mirror is mounted at the end of a tube as in Fig. 6 and may be sighted on the contents of the furnace or on to a tube with a closed end inserted through the furnace wall.

For taking high temperatures rapidly and especially where portability is an asset, an optical pyrometer is exceedingly useful. A popular type is the "disappearing filament pyrometer," so called from the principle on which it works (Fig. 7). It consists of a telescope through which the observer sights on to the object or hot surface of which he wishes to measure the temperature. An electric light bulb is fitted into the tube of the telescope so that the lamp filament crosses the image of the hot surface. An adjustable resistance in the circuit enables the observer to adjust the brightness of the filament until it just matches the background. At this point the filament cannot be distinguished from the hot surface and disappears (Fig. 8). An ammeter in the circuit is calibrated so that the temperature can be read directly, corresponding as it does to the current through the lamp filament. The whole outfit, which is self-contained and includes a battery to supply the current, has been used extensively in iron and steel foundries. An obvious precaution when using either the radiation or optical pyrometers is to see that no smoke or fumes drift between the instrument and the object under observation.

Low. Correct High.

FIG. 8.—OPERATION OF THE DISAPPEARING FILAMENT.

Automatic Control

Automatic temperature control is now frequently employed with the object of maintaining steady temperatures. The regulator is set at the desired temperature, to eliminate the heating medium, whether steam, gas, oil or electricity, immediately that temperature is reached. If, however, the temperature falls due to the charging of the furnace with fresh work, the medium is turned on again to raise the temperature as quickly as possible.

All the different types of pyrometers mentioned above, with the exception of the optical pyrometer, can be adapted for automatic regulation. The dial thermometer may be arranged to operate directly in the case of gas (Fig. 9) or may be fitted with electrical contacts for operating electrically operated valves or circuit breakers. Such contacts are shown in Fig. 1.

In the case of thermo-electric and radiation pyrometers, the pointer cannot be used to make direct contact and it is depressed periodically as in the recorder to open or close a switch, depending on its position with respect to the control point.

One of the simplest automatic regulators for use with thermo-couples is illustrated in Fig. 10. This is a type of potentiometer in which the electromotive force due to the thermo-couple is balanced against that from a standard cell. The galvanometer pointer indicates that the temperature is correct when in the central position and moves to the right or left as the temperature rises or falls. The regulator is set to the desired control temperature by a hand adjustment.

FIG. 6.—RADIATION PYROMETER.

Fig. 10 illustrates the instrument with cover opened showing the control mechanism and mercury switch. The galvanometer pointer P swings horizontally below two bell-crank levers L, L_1, and above a clamping jaw C which is periodically raised, thus clamping the pointer against one or other of the levers L. Hinged to the jaw C is a long tail rod R passing through a guide-hole in a tilting "T" piece B, and terminating in a shoe piece F. The "T" piece B is tilted to one side or the other by movement of the levers L or L_1, thus also tilting the tail rod R. The action of the mechanism is as follows:—Suppose the temperature being controlled varies slightly from the control point; the galvanometer circuit will be thrown out of balance, and the pointer will move to one side, say, towards the left (Fig. 10). When the jaw C rises, it will therefore clamp the pointer P against the lever L, and raise the lever slightly, thus causing the piece B to tilt to the left, which in turn tilts the rod R in the same direction. When the jaw C falls, the shoe piece F on the rod R comes into contact with a projection G on a bracket pivoted at E, which carries the mercury switch S, and this switch is thereby tilted over, breaking (or making) the circuit controlling the supply of heat. If the galvanometer pointer were deflected towards the right, the lever L_1 would be

FIG. 9.—AUTOMATIC GAS REGULATOR.

operated, and the switch would be tilted in the opposite direction.

Normally the mercury switch is provided with two positions only, *i.e.*, with the contacts either made or broken. If desired, however, a two-way tube with a common centre contact may be fitted, which will close one circuit when the temperature is too low, and close another circuit when it is too high, both circuits being open when the temperature is correct.

The current for the potentiometer circuit, which is supplied by a large capacity dry cell, can be easily standardised by adjusting a rheostat operated by means of a removable knob; an arrow engraved on this knob indicates when the dry cell requires renewing. The instrument is enclosed within a dust-proof case provided with a cover so designed that when it is open all parts of the mechanism are easily accessible. It can be calibrated for use with base- or rare-metal thermo-couples or for radiation pyrometers. Similar mechanisms can be used with an indicating type of regulator or with a combined recording and regulating potentiometer, the arrangement being varied to meet the special conditions prevailing. The general principles, however, are well illustrated by this simple type of instrument.

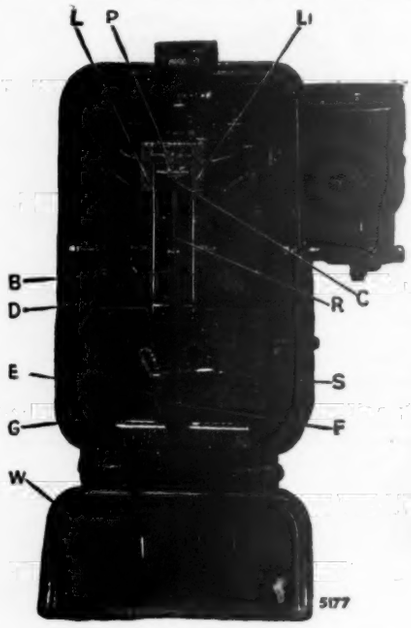


FIG. 10.—AUTOMATIC REGULATOR FOR USE WITH THERMO-COUPLES.

In the case of electrically-heated furnaces, the controller switch makes or breaks the furnace current through a suitable contactor which opens or closes the switch contacts as the temperature rises or falls. With gas- or oil-fired furnaces the temperature is regulated through valves operated by electric motors. The valve operating gear illustrated in Fig. 11 is designed for operating air, gas, steam, water or other valves, of either the "butterfly" or the "screw-down" types. It can be arranged to operate either one or a number of valves and may be applied to the majority of existing valves or dampers. Where desired, suitable valves can be supplied with the gear. A useful application is the control of natural-draft gas-fired furnaces, where it is necessary to close the damper as the amount of gas fuel is reduced.

The gear comprises a small electric motor M, coupled to a gear box G, incorporating a speed reduction gear. On the shaft of the gear box are mounted two friction-tight discs D, D_1, each carrying a projecting piece P, P_1, which, when the discs rotate, engages with one of two levers L, L_1, controlling the position of a double reversing mercury tube switch S. The gear may be used in conjunction with the potentiometric controllers described above, or with a mercury-in-steel index thermometer (see Fig. 1). When the temperature falls below the control point, the controller operates to start the motor on the valve operating gear, thus rotating the gear in such a direction as to open the valve (or damper). After a predetermined amount of rotation, one of the disc projections (say P) is brought against the reversing switch lever L, tilting over the mercury switch S and thus stopping the motor, the switch being left in such a position that when next started the motor will rotate in the reverse direction. When the temperature has risen beyond the control point, the motor is automatically started again by the controller, thus operating the valve in the reverse direction, and after a certain amount of movement has taken place the projection P_1 on the second disc D_1 throws the reversing switch S back to its original position, at the same time stopping the motor. The relative position of the projections on the two friction discs can be readily adjusted to provide any desired movement of the valve from little more than zero up to 350 angular degrees. The gear gives a slow rate of opening and closing to the valve as compared with a snap action valve and thus reproduces the most valuable feature of hand operation.

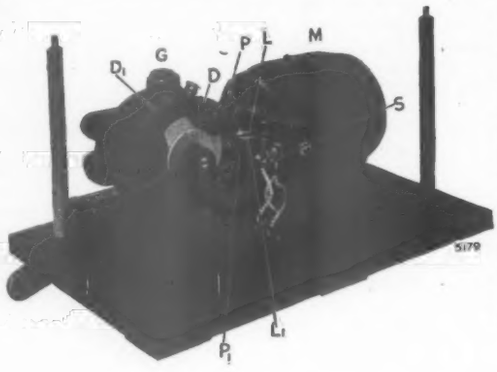


FIG. 11.—VALVE OPERATING GEAR.

With this type of regulator, the valve is so adjusted that it is open either slightly too far or too little, and it is moved from one position to the other with sufficient frequency to keep constant the temperature being controlled. The gear can be set so as to reduce the amount of valve movement to the minimum amount necessary to give effective control, and by this means large fluctuations in the supply of fuel or air are avoided. If the conditions of the process under control should change by a large amount however (*e.g.*, by altering the loading of a furnace, or a considerable change in the pressure of the fuel supply), a hand adjustment can be readily made to the positions of the disc projections, in order to modify the valve opening to suit the new conditions.

Conclusion

The author has endeavoured in this Paper to deal briefly with the various types of apparatus available for controlling temperatures encountered in the process of enamelling. Limitations of space have prevented exhaustive treatment of many aspects, but it is hoped that a general view of the subject has been presented, which will be of some interest and assistance to the members of the Institute.

The author wishes to thank those who have helped him with the preparation of this Paper. He has also to acknowledge the kindness of the Cambridge Instrument Company, Limited, in lending illustrations for this Paper.

Mould Facings for Cast Iron and Their Effects upon Vitreous Enamel*

By H. McNAIR

The growth of interest in sand preparation and conditioning for all grades of foundry work has been reflected, in recent years, in a wealth of information upon this subject, with a consequent gain to the moulding shop. This, with a better understanding of the properties and the control of cast iron than existed a generation ago, is tending to produce a better product from the founder's viewpoint. Where such products are enamelled, however, it would appear that these benefits are not shared to the same extent by the enameller, and it is not surprising to find that there still is a difference of opinion regarding the use of facings for moulds and their effects upon enamel during the process of application.

Many practical founders regard carbonaceous facings as a contributory, if not the chief cause of blistering, and reason that the carbon from the facing enters or is absorbed into the surface of the casting during the period of cooling, and that this carbon burns out during the enamelling process. It may be argued, however, that efficient annealing would greatly reduce the risk or that care in the shot-blasting of the castings would entirely remove any traces of the mould facing from the metal.

Pitting and mapping on flat surfaces are another source of annoyance to the enameller, as these defects are rarely visible until after sand-blasting, and one or more coatings of enamel may only serve to emphasise the irregularities. Opinion is divided as to the cause, non-metallic impurities in the metal sulphide segregation and unsuitable or badly-conditioned sand being held equally responsible for the trouble. Other defects may be formed by changes in the quality of the sand and from damp spots resulting in variations in the structure of the metal, but blistering and surface irregularities appear to be the two main defects attributed to sand and mould facings by many grey-iron founders and enamellers.

Blistering, pinholing and boiling appear to have a common origin and arise from the evolution of gas from the metal, or from the surface of the metal. Provided the gas penetrates through the enamel layer, and the latter is sufficiently fluid to fill in the vent-holes formed, no trouble will be found, but where gas has pierced the enamel, and the latter is not sufficiently fluid to refill the vent, a pinhole remains. Where gas evolution has occurred to any great extent, large areas of the surface may show evidence of the agitation, resulting in the effect known as boiling or bubbling. Gas from the metal may arise from several sources. First from gases entrapped in blowholes, graphite cavities, draws and porous areas. In this category may be included CO, CO_2, H_2, H_2O vapour and N_2, H_2, N_2 and O_2 may also be combined with the metal or with its constituents, forming hydrides, nitrides and oxides. Again, gas may actually be dissolved in the metal in solid solution, leaving no more trace of its presence than salt dissolved in water. Gases from the facing

* Paper read before the Scottish Section of The Institute of Vitreous Enamellers.

may be included in the latter, as these may possibly find their way into the metal under certain conditions.

Previous Work Reviewed

It is of interest at this point to note, in a brief *résumé*, the observation and conclusions of some prominent investigators of the problem. Kerstan states that the presence of hard sulphur compounds, spongy cast iron and local graphite precipitation *on* the iron, will give rise to pinholing. Blistering irons are stated to be mainly high in sulphur (Poste) and a pearlitic structure is said to be detrimental, *i.e.*, graphite and free ferrite is beneficial. Sponginess in the iron causes blistering, as does also a high-Mn content (Krynitsky and Harrison).

Muller states that high-S irons exhibit blistering tendencies, even when the S exists in its least harmful condition as MnS, and that the presence of iron oxide is a contributory cause. Norbury found that in an unannealed casting the thinnest section shows most blistering, and also that a chill causes blistering. Views opposite to the last have been expressed by A. Malinovsky and M. Manson in the Proceedings of the American Ceramic Society. They both agree that low T.C and maximum pearlite give best results.

Harrison found that pinholing was eliminated by removing the surface layer either by machining, grinding or by chemical means. W. and O. Kerstan state (in "German Enamel Industry") that spots in castings are due to ferric-sulphide spots. These sulphide inclusions appear as brown spots after annealing. In "German Enamel Industry" it is stated that dust entering the enamel during the process results in bubbling and pinholing.

The theory has recently been advanced by the B.C.I.R.A. that pinholing may be caused by a reaction between partly-oxidised graphite flakes which still contain graphite to react with oxidised iron immediately enveloping the flakes.

These views, representing as they do only a small part of the conflicting mass of opinion, appear to indicate that pinholing and like defects may arise from several distinct sources or causes, and not to any one particular fault in the material or in the subsequent treatment. It may well be, therefore, that the use of a particular type of iron may eliminate several possible sources of trouble, thereby reducing the limits. The use of non-carbonaceous facing materials will have a similar effect, as will also the careful treatment of the castings during the enamelling process.

Extreme caution must be observed in construing any results or observations from any one particular investigation, as nowhere does the old adage "What is one man's meat is another man's poison" apply with more effect than in the foundry.

Materials used for Investigation

The moulding sands and facings used in this brief investigation are typical of those found in Scottish light casting foundries, where strength and refractoriness appear to be secondary properties, and the ability to part clean from the casting and give a fine smooth finish are the main essentials.

Table I shows the analyses of the sands used. Three raw sands, the foundry floor or backing sand and a synthetic sand composed of sea sand and bentonite were considered sufficient for examination as they cover a fairly wide range so far as analysis and properties are concerned. The synthetic sand was prepared by milling for 8 min. in a pan mill, and when tested in the B.C.I.R.A. compression apparatus, showed a strength of 7.3 lbs. per sq. in. The moisture was 5.6 per cent. and the permeability figure between that of the rock sand and the Erith. The sands were only used as facings and were backed by the shop floor sand in the usual way.

The facings used were all carbonaceous, and include (1) a coal-dust facing composed of:—Coal-dust, 5 per cent.; Erith, 95 per cent. Nos. (2) and (3) are blackings; (4) is a typical plumbago, and (5) is lamp black. Nos. (2), (3), (4) and (5) were dusted on the mould in the usual manner, and Table II shows the approximate analysis of the series.

It was decided to examine the effects of the sands and facings by casting test-bars similar to the Keep's bar, *i.e.*, 12 in. long by ½ in. square, and casting four of these bars in the same facing and with the same metal. As only one set of four was made each day, there is probably a difference in the quality of the metal, between the various sets, although the following analysis shows very little variation:—T.C, 3.2 to 3.4 per cent.; C.C, 0.3 to 0.4; Mn, 0.55 to 0.70; Si, 2.70 to 2.90; P, 0.90 to 1.05; S, 0.06 to 0.075.

TABLE I.—*Analyses of Sands Used. Per cent.*

	Erith type.	Mansfield type.	S.R. Rock type.	Bentonite.
SiO_2 ..	90.51	90.20	81.43	62.57
Al_2O_3 ..	3.94	2.14	5.74	22.45
Fe_2O_3 ..	2.16	2.98	2.02	3.89
TiO_2 ..	0.23	—	0.12	0.75
CaO ..	0.20	0.28	2.82	2.46
MgO ..	0.31	0.31	0.61	0.30
Alk. ..	1.70	—	2.73	0.20
Loss on Ignition	0.95	2.15	5.03	6.18
Fusion Point, Deg. C.	1,540	—	1,510	0.80 1,340

Synthetic Sand: Sea Sand + 3 per cent. Bentonite.

Each set was treated and enamelled the day after casting and any pinholing defects noted. The bars were then placed under strain in a small transverse test machine and the extent of crazing or cracking of the enamel noted with increasing deflection. The deflections and the extent of cracking, etc., have been noted and are shown with other data in Table III. While it is not maintained that these figures reflect the true value of the enamel grip, it is believed they are a fairly strong indication of the bond between the enamel and the metal surface. It is possible, therefore, assuming other details of treatment, such as shot-blasting, to be the same in all cases, that the results reflect the effect of the facing or sand used.

In each set of tests No. 1 bar (Fig. 1) was annealed at 800 deg. C.; shot-blasted at 60 lbs. pressure; under-coat fired at 800 deg. C., and the cover coat fired at 780 deg. C. This follows the usual commercial practice. No. 2 bar was annealed at 800 deg. C., but only lightly cleaned with a stone and brushed, and was not shot-blasted. It was then under and cover coated in the usual manner. No. 3 was not annealed, but was sand-blasted at 60 lbs. per sq. in. pressure, and finished as before. No. 4 was neither annealed nor shot-blasted, but was "stoned" and brushed and finished as before. This routine was adopted throughout the series of tests, with the object of examining the effect of removal of the surface coating and of annealing. In several cases the bars were weighed before and after blasting and an approximation of the weight of metal removed was made. From the surface area of the test-bar the actual thickness of metal removed was calculated. The maximum loss was found to be 0.00115 in. or 0.003 cms. and the minimum to be 0.00077 in. or 0.002 cms. In loss of weight this corresponded to 0.0003 lbs. per sq. in. or 0.0200 gms. per sq. cm. and 0.0002 lbs. per sq. in. or 0.0159 gms. per sq. cm.

TABLE II.—*Analyses of Carbonaceous Facings Used. Per cent.*

	Coal-dust.	Plumbago.	Wood black.	Pat. black.	Lamp black.
H_2O ..	4.12	1.46	5.16	1.10	6.80
Volatile ..	33.38	0.89	11.99	4.05	18.28
Ash ..	14.00	12.95	11.80	26.62	29.06
Fixed carbon	48.50	84.70	71.05	68.23	45.86

The annealing and enamelling of all the test-bars was carried out in the laboratory in a gas-fired muffle, the temperature being regulated with the aid of a temperature indicator of the thermocouple type.

Tables III and IV indicate the method of treatment and whether pinholing of the enamel took place. The deflection of the bar at first sign of crazing or cracking of the enamel has been noted, and this figure, approximate as it undoubtedly is, might possibly be regarded as the point at which the bond between metal and enamel, whether it be mechanical or chemical, is first broken. The deflection at the breaking point of the bar has also been noted along with a note of the crazing and the lineal extent of the crazing. Unfortunately, it was impossible to obtain the bars, as cast, with exactly the same cross-sectioned area, and this, ignoring the effect of the constitution of the metal, has affected the final deflections, and therefore the extent of the final crazing or cracking. The latter figures, however, vary within such comparatively wide limits as to suggest that they do bear a close relationship to the metallic surface, and therefore to the pre-treatment of the bars. The last two factors are also very approximate, the nature of the grip between enamel and metal having been judged by the appearance of the underside of the enamel when removed from the bar. Pieces were examined at a low magnification and noted as either predominantly enamel or metallic. Grips noted as being almost wholly enamel had a creamy or dirty white colour, with very little trace of the dark-brown or black chemical compound due to the fusion of the enamel with the metal or metallic oxide. Grips which had almost wholly this dark brown or black appearance due to chemical combination have been noted as Fe, and grips having patches of both E (enamel) and Fe have been assessed as accurately as is possible by visual means, and the percentage of each noted. The resistance to chipping is a very unreliable figure, but has been included because of the questionable faith many practical enamellers have in this method of testing enamel and its grip.

Pinholing

Examining the group of sand facings (Table III) it is seen that there is no trace of pinholing where the bar has been annealed and shot-blasted. This applies to all five sands. In bars No. 2, however, where the bars have been annealed but only "stoned," slight pinholing was observed in all cases. Set 3, shot-blasted without annealing, showed no trace of pinholes with any of the sands, but in the case of set 4, where the bars were only cleaned by rubbing with a stone before enamelling, the Erith, Mansfield and floor sands all showed traces of pinholes. The Scottish rotten rock and the synthetic sands were without any trace of defects. These results appear to indicate that whilst no trouble will accrue where enamelling follows shot-blasting without annealing, there is a danger of pinholing where shot-blasting is omitted after annealing From this it would follow that during annealing there is a change in the metal which tends to promote pinholing, and as set 1 shows that shot-blasting following annealing forms no defects, the first conclusion is that the cause of the pinholing is a surface change, probably the surface oxidation of the metal which is clearly seen on all castings which have been annealed.

Crazing or Cracking

From Table III, showing the extent of the cracking of the enamel under strain, it is apparent that the best results are again obtained on sets 1 and 3, *i.e.*, where the bars have been shot-blasted. Of the five sands, however, the Scottish rotten rock and the synthetic sands are the only ones which resulted in complete freedom of cracking on either side of the bar fracture. In the case of all sands, however, sets 2 and 4 gave equally poor results, indicating a probable relationship between sand-blasting and cohesion. In the case of the Mansfield sand, enamelling

following only stoning of the metal, resulted not only in very bad cracking, but in the breaking away of a piece about 3 in. in length from the surface.

An examination of the figures for appearance of the grip shows the rock sand, synthetic sand bars to have somewhat similar cohesive properties. In the case of bars 1 and 3 in each case, the undersurface shows a larger area of the creamy enamel than the dark ferrous compound. It might be thought that a false impression is being made and that the ferrous compound grip has parted from the enamel, thereby showing these light patches, but in the extreme case of the synthetic sand the metal surfaces of bars 1 and 3 were almost free from the dark compound where the enamel was chipped off, showing that the greater part of the grip was mechanical. The bars cast in the Mansfield sand were particularly high in ferrous compound grip, together with those of the floor sand approaching the condition of the Erith sand bars.

The resistance to chipping, which incorporates the human element, cannot be relied upon to any great extent, but for such as it is worth it appears to show a relationship to the nature or appearance of the grip. Bars with the greatest resistance to chipping are sets 1 and 3 with those of the Erith, rock and synthetic sands showing most resistance. Again, the Mansfield cast bars give the poorest results, with those of the floor sand somewhat better.

So far this Paper has established that resistance to chipping, and to a lesser degree crazing, of the enamel under strain, appear to be functions of the nature of the cohesion and that the best results are obtained from those grips which show themselves as being more of a mechanical nature than a chemical one. When cast, the bars differed as regards fineness of skin, the Mansfield sand giving a fine finish, the rock a medium course, and the remaining three sands a course finish. When shot-blasted, however, all bars appeared to be of the same degree of roughness. Such pinholing as has been observed is insufficient to justify a relationship to either the nature of the sand or the nature of the cohesion, but suggests that the omission of shot-blasting or improper cleaning may result in the appearance of such defects.

(*Concluded on page* 452.)

TABLE III.—*Influence of Sand on Enamelling Properties.*

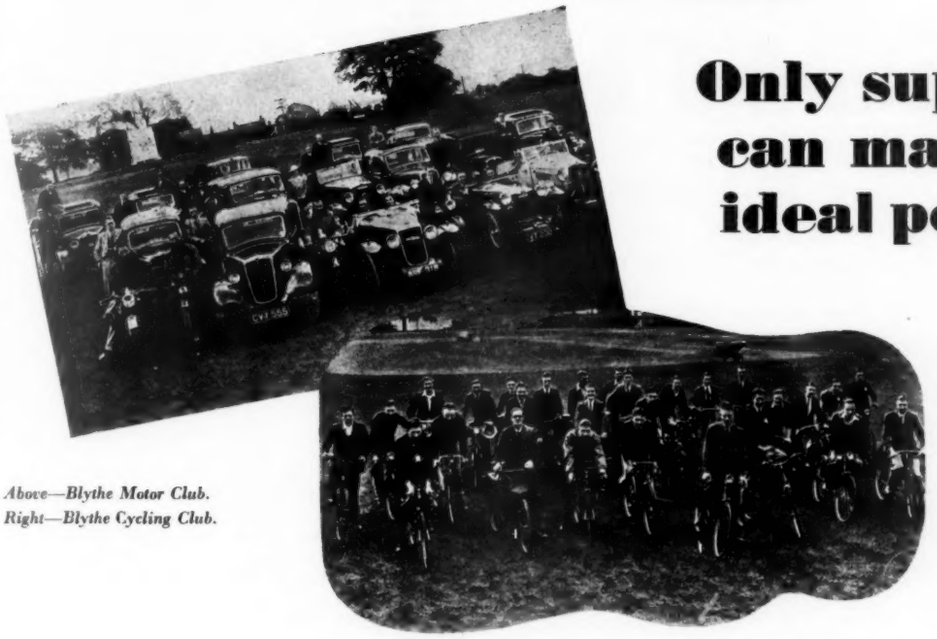
Bar No.	Erith type coarse skin.				Mansfield type med. fine skin.				Scot. rott. rock type med. coarse skin.				Floor sand coarse skin.				Synthetic sand coarse skin.			
	1.	2.	3.	4.	1.	2.	3.	4.	1.	2.	3.	4.	1.	2.	3.	4.	1.	2.	3.	4.
Annealed at 800 deg. C.	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
Stoned	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Shot-blast at 60 lbs. per sq. in.	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
G-coated at 800 deg. C.	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same
Cream-coat at 780 deg. C.	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same
Pinholing	None	Slight	None	Slight	None	Very Slight	None	Very Slight	None	Slight	None	None	None	Slight	None	Slight	None	Slight	None	None
Deflection at first sign of cracking, in.	0.125	0.123	0.068	0.135	0.070	0.070	0.070	0.075	None	0.075	None	0.080	0.065	0.06	0.070	0.06	None	0.076	None	0.070
Deflection at breaking, in.	0.161	0.162	0.165	0.174	0.180	0.191	0.190	0.192	0.137	0.141	0.174	0.170	0.160	0.158	0.164	0.165	0.147	0.140	0.158	0.441
Cracking	Fair Bad	Very Bad	Bad	Very Bad	Bad	Bad	Fair	Very Bad (Flew Off)	None	Very Bad	None	Very Bad	Fair	Bad	Fair	Very Bad	None	Bad	None	Very Bad
Lineal extent of cracking, in.	2	5	2½	4½	2	3	2½	6	0	4	0	5½	1	2½	1½	4½	0	3½	0	5
Appearance of grip ..	75 E 25 Fe	30 E 70 Fe	75 E 25 Fe	0 E 100 Fe	20 E 80 Fe	0 E 100 Fe	10 E 90 Fe	0 E 100 Fe	75 E 25 Fe	10 E 90 Fe	75 E 25 Fe	0 E 100 Fe	40 E 60 Fe	10 E 90 Fe	40 E 60 Fe	10 E 90 Fe	90 E 10 Fe	10 E 90 Fe	90 E 10 Fe	10 E 90 Fe
Resistance to chipping	Very Good	Good	Very Good	Fair	Poor	Very Poor	Poor	Very Bad	Very Good	Poor	Good	Very Poor	Good	Poor	Good	Bad	Very Good	Poor	Very Good	Poor

TABLE IV.—*Influence of Facings on Enamelling Properties*

Treatment.	Coal-dust facing, med. smooth.				Wood blacking, smooth finish.				Pat. blacking, smooth finish.				Plumbago, very smooth.				Lamp blacking, med. smooth.			
	1.	2.	3.	4.	1.	2.	3.	4.	1.	2.	3.	4.	1.	2.	3.	4.	1.	2.	3.	4.
Annealed at 800 deg. C.	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
Stoned	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Shot blasted at 60 lbs. per sq. in.	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Ground coated at 800 deg. C.	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same
Cream coated at 780 deg. C.	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same
Pinholing	None	Slight	None	None	None	Bad	None	Bad	None	Slight	None	Slight	None	Slight	None	Fairly Bad	None	None	None	Slight
Deflection at first sign of cracking, in.	None	0.100	None	0.113	0.063	0.060	0.083	0.081	0.080	0.073	0.075	0.076	0.105	0.080	0.120	0.100	0.077	0.082	0.080	0.082
Deflection at breaking, in.	0.151	0.168	0.164	0.170	0.155	0.163	0.171	0.185	0.135	0.140	0.143	0.123	0.178	0.148	0.145	0.150	0.181	0.176	0.180	0.184
Cracking	None	Light Crack	None	Bad Crack (Flew Off)	Light	Very Bad (Flew Off)	Light	Bad	Fair	Very Bad (Flew Off)	Very Bad	Very Bad (Flew Off)	Bad	Very Bad (Flew Off)	Bad	Very Bad	Fair	Bad (Flew Off)	Bad	Very Bad (Flew Off)
Lineal extent of cracking, in.	0	1¼	0	4	1	2¼	1	2½	1¼	4	3	3¼	3	3	2¾	3	1½	1½	2	2½
Appearance of grip ..	60 E 40 Fe	5 E 95 Fe	60 E 40 Fe	25 E 75 Fe	70 E 30 Fe	0 E 100 Fe	80 E 20 Fe	5 E 95 Fe	5 E 95 Fe	0 E 100 Fe	5 E 95 Fe	0 E 100 Fe	50 E 50 Fe	10 E 90 Fe	10 E 90 Fe	0 E 100 Fe	80 E 20 Fe	5 E 95 Fe	80 E 20 Fe	5 E 95 Fe
Resistance to chipping	Very Good	Poor	Good	Very Poor	Good	Very Poor	Very Good	Very Poor	Poor	Very Poor	Poor	Very Poor	Very Good	Good	Poor	Fairly Good	Good	Fair	Good	Poor

IN THE INTERESTS OF THE WORKERS

Talk No. 1.



Above—Blythe Motor Club.
Right—Blythe Cycling Club.

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The results of the test on the carbonaceous facings have been tabulated in Table IV as before, and again it is found that with one exception no pinholing appears where the bars are properly shot-blasted. The exception is bar 3 of the coal-dust series where a few very small holes were noted. With reference to the extent of the crazing or cracking of the enamel under strain, the bars cast with the coal-dust facing gave very good results, particularly in bars 1 and 3, where no cracking of the enamel took place on either side of the bar fracture. The order of resistance to cracking appeared to be:—(1) Coal-dust facing; (2) patent blacking; (3) lamp blacking; (4) wood blacking, and (5) plumbago.

A glance at Table II of these five facings eliminates any question of relationship between cracking and volatile, ash or fixed carbon.

In the figures for appearance of grip the dark coloured chemical bond has again been noted as Fe, but in all cases in this group the bond material was almost black in colour and appeared, under low-power magnification, to be contaminated with carbon, graphitic or otherwise.

The resistance to chipping appears to depend greatly on the nature of the grip, and as was found to be the case with the green-sand facings,

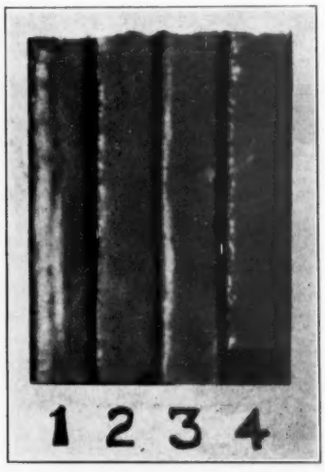

FIG. 1.

the resistance to chipping and the extent of the cracking both indicate to some extent a relationship to the nature of the grip.

Summarising the results in this group, it would again appear that cracking and chipping are reduced to a minimum with the maximum bond described here as mechanical bond, and that this type of bond is more readily obtained by shot-blasting.

The order of merit of results cannot, with reliability, be traced to any factor in the proximate analysis, unless it be the volatile content. It may be more than singular that coal-dust, with the highest volatile content, should give best results, and that plumbago and patent blacking should be relatively bad.

Hird, in a Paper* read before the Institute of British Foundrymen upon coal-dust in facing sands, stated that, from the gaseous matter liberated from coal-dust during pouring and solidification of metal, carbon was adsorbed by, or diffused into the metal surface, and he showed some total carbon figures in support of this statement. By machining off the surface layer of the metal, he showed that this outer skin had a higher total carbon content than the underlying metal. A difference in the total carbon content itself may not seem at first any concrete reason why one metal should enamel better than another, but in the light of much work carried out more recently upon the oxidation rates of various forms of carbon, it may be that there is sufficient ground for further examination of this question.

Most foundrymen are aware that in dealing with foundry coke the analysis gives no indication of the combustibility of the material, *i.e.*, the free-burning quality. After much painstaking work upon this subject, the Northern Coke Research Committee, under the directorship of Prof. H. L. Riley, devised a comparatively simple apparatus for determining the combustibility or rate of oxidation of carbonaceous materials. Table V shows oxidation rates of various types of carbon in mgms. of carbon dioxide evolved per 2.5 hrs., and illustrates that it is the nature of the carbon which determines the ease of combustibility.

TABLE V.—*Rates of Oxidation of Different Forms of Carbon.*

	CO_2 evolved in 2½ hrs. in m.g.s.
Diamond	43
Graphite	824
Sugar charcoal	42
Electrical carbon	1,094
Wood charcoal*	328
Retort carbon	258
Anthracite	86
Pitch coke	239
Petroleum coke	367
Petroleum	392

* On recarburising wood charcoal at high temperature: 570 m.g.s. in 2½ hrs.

It is possible, therefore, that the use of various carbonaceous facings results in adsorption of different forms of carbon, with different reactions or oxidation rates during the enamelling process, and that this may account for the differences in pinholing and cohesion of enamel to the metal.

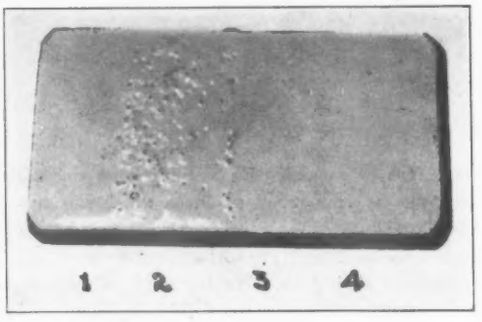

FIG. 2.

It was decided to repeat the series of tests using a rectangular plate 5 in. by 2.5 in. by ¼ in., and these were made in the same sands and facings as before. The plates were sectioned off in four parts and treated in the same way as the bars had been. Fig. 2 shows one of the resultant plates, cast in rock sand, showing bad pinholing in section 2. This part, like No. 2 in the bar series, was annealed, but only cleaned by stoning and brushing, the resistance to chipping and the appearance of the grip of the four sections were approximately in line with those of the test-bar series. This applied to all sands and carbonaceous facings used, the results being close enough to justify some claim to corroboration.

It is fairly evident that pinholing and blistering of the enamels is not the result of any one fault in the material or the process. The final result may be similar, but can be arrived at by different moulding and process methods. This, unfortunately, makes the problem more difficult than at first sight.

Influence of Rust

The tests on carbonaceous facings suggest that adsorbed carbon may be a possible source of trouble, while those on the green sands suggest contamination by one or more of the sand constituents, or possibly varying degrees of oxidation of the metal skin. It has often been suggested that ferric oxide (Fe_2O_3) is one of the causes of pinholes, and the presence or absence of this on the green-sand test-bars may have influenced the results to some extent. Practical enamellers have always stated that rust on cast iron will result in pinholing or breaking away of the enamel coat, despite annealing and sand-blasting of the casting. This can only result by reaction between the oxide and some other constituent in either metal or enamel, or by reduction of the ferric oxide to ferrous oxide with the liberation of oxygen. With this in mind, a few laboratory tests were carried out on cast iron with varying degrees of surface rust. These were annealed and cleaned in the usual manner and enamelled, the results indicating that blistering increased with surface rust appearance.

Small pieces of rusty metal were then immersed in molten enamel at 900 deg. C. in a small crucible. Evolution of gas was observed almost instantly, and bubbles were liberated in some cases for over half an hour before the rate of evolution was considered sufficiently slow to cease the test. Rust was then tried alone, in the form of small pellets, and the same results observed. It is therefore apparent that rust, or moist ferric oxide, is one source of pinholing.

Samples of rust, similar to that used in the above tests, were heated in a drying oven for two hours and the losses in weight found to be 6.6 per cent. and 8.9 per cent. respectively. The samples were then further heated for half an hour at a temperature of 800 deg. C. and further losses in weight of 3.8 and 4.0 per cent. were found. Increasing the temperature to 900 deg., the samples were heated for a further half hour, and the loss in weight found to be 6.2 and 7.4 per cent. respectively. Further heating at 900 made little change in the figures, the final losses after two hours being 6.4 and 7.5 per cent.

This would suggest that, even at temperatures below 900 deg. C., ferric oxide is partly reduced to the magnetic or the ferrous oxide, and it is possible that under reducing conditions during enamelling, if such exists, a considerable amount of ferric oxide may be present, and this may partly be reduced to Fe_3O_4 or FeO, with liberation of oxygen to cause blistering or pinholing. Small pellets of ferrous oxide were then immersed in the molten enamel, but no evolution of gas was noted.

Pellets of the carbonaceous facings, free from moisture and volatile matter, were also tested by immersing in molten enamel at 900 deg. C., and in all cases evolution of gas was noted to a greater or less degree. It is therefore apparent that carbon, in one or more of its forms, can give rise to pinholing.

With reference to the cracking of the enamel under strain and the extent of the cohesion of the enamel layer, these appear to have some relation to each other, and the results obtained suggest that the dark coloured ferrous-silicate bond is inferior to the lighter coloured bond which appears to be a mechanical one. This is contrary to the previously accepted views upon this subject, but as there appears to be no reliable method of determining the relative values of the two types of grip, little more can be said upon the point. Certainly there is no reason to suppose that a good mechanical bond is in any way inferior to what is, after all, a relatively weak and brittle chemical compound.

PARTICULARS WERE PUBLISHED last week, in connection with an application to the Committee of the Stock Exchange for permission to deal in the stock of an issue of £225,000 4½ per cent. debenture stock of George Kent, Limited, manufacturers of meters, brassfounders and general engineers. The business is nearly 100 years old.

* FOUNDRY TRADE JOURNAL, June 27, 1929, p. 493.

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This Week's News in Brief

Trade Talk

BARTRAM & SONS, Sunderland, have received an order for a 9,000-ton ship for Australian owners.

ABOUT FORTY MEMBERS of the Derby Society of Engineers recently visited the works of Qualcast, Limited, Derby.

BROWN, BAYLEY'S STEELWORKS, LIMITED, Sheffield, are extending their machine shop and mill. A modern plant for testing steels is also to be erected.

FIVE STEAM DRIFTERS from the North of Scotland have been beached at the Bridgeness shipbreaking yard of P. & W. MacLellan, Limited, for scrapping.

A NEW MILLING PLANT, manufactured by John McNeil & Company, Limited, Glasgow, has been installed at Uganda (Kaleira) Sugar Works, Limited, South Africa.

E. H. JONES (MACHINE TOOLS), LIMITED, have recently transferred their Midlands showrooms and branch office to larger premises at 14, Florence Street, Birmingham.

THE OLD WORKS of the Brandon Bridge & Engineering Company, Motherwell, which have been closed for many years, have been acquired by the Trussed Concrete Steel Company, Limited, London.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, have received an order for eleven locomotives from the Federated Malay States Railways. The engines are to be of the 4-6-2 class, with double bogie tender.

THE PRIME MINISTER OF TURKEY visited the Corby works of Stewarts and Lloyds, Limited, on Whit Monday. A steel producing plant, on similar lines to that at Corby, is being laid down in Turkey by H. A. Brassert, Limited, who were consulting engineers for the Corby works.

A CONTRACT has been received by the machinery department of Edgar Allen & Company, Limited, for a large rotary kiln shell measuring 200 ft. in length by 13 ft. 6 in. dia. at one end and 8 ft. 6 in. at the other. The kiln shell has been ordered by Imperial Chemical Industries, Limited, of London.

DELEGATES to the 34th Annual Conference of the Institute of British Foundrymen will be given a civic welcome on June 8. On Wednesday, June 9, a visit has been arranged to Ley's Malleable Castings Company, Limited, Derby, Qualcast, Limited, Derby, and Bamford's, Limited, of Uttoxeter. On Thursday afternoon parties will visit the Stanton Ironworks, Herbert Morris, Limited, Loughborough, and the Loughborough Engineering College. Mr. F. D. Ley is chairman of the reception committee with Mr. S. H. Russell hon. treasurer. Other members include Sir Arthur Aiton, Dr. W. A. Richardson, Mr. V. Jobson, Mr. E. J. Fox, Mr. C. Bamford, Mr. S. A. Gimson, Mr. H. H. Moore, and Dr. H. Schofield.

THE ANNUAL CONFERENCE of the representatives of Carron Company with the works and managerial staffs at Falkirk was held on May 21. Afterwards the party travelled by motor coaches through the Glasgow and Clydeside industrial area to Tarbet, where lunch was served. Mr. George Pate, O.B.E., J.P., the general manager, who presided, expressed the hope that the visit of the representatives of Carron would be to the benefit of all the staff. Such visits led to greater tolerance and more effective co-operation, while the happy social intercourse fostered the spirit of fellowship. After lunch the party passed through Glen Falloch to Crianlarich and Glen Lochy to Dalmally, Inverary, Loch Fyne, Loch Long back to Tarbet for tea. Mr. H. Bell, foundries commercial manager, proposed a vote of thanks to Mr. Pate for arranging the outing and for accompanying the party. Mr. W. C. Danerel, South West England representative, conveyed the thanks of the representatives.

Obituary

THE DEATH HAS OCCURRED at the age of 92 of Colonel Edward Henry Nicholson, M.A., J.P., a director of W. N. Nicholson & Sons, Limited, steel and malleable ironfounders of Trent Ironworks, Newark-on-Trent.

MR. JOHN BARNSLEY, who died recently at the age of 75, was formerly a director of John Barnsley & Sons, Limited, brassfounders, Excelsior Brass Works, Abbeydale. He was the son of the late Mr. Isaac Barnsley, who founded the business.

Personal

MR. RABOZÉE, professor at the Military College, Brussels, has been made a Grand Officer of the Order of the Crown.

MR. M. REY, professor of special metallurgy at Liége University, has been nominated a Chevalier of the Order of Leopold.

MR. H. THYSSEN, professor at the Liége University, has had the honour of Officer of the Order of the Crown conferred upon him.

PROF. F. PISEK, President of the Czecho-Slovakian Foundrymen's Association, has been decorated by the French Government with the Cross of Chevalier of the Legion of Honour.

MR. S. THOMSON, of the Dalzell Steel Works of Colvilles, Limited, has been appointed works manager of the Lanarkshire Steel Works of the Lanarkshire Steel Company, Limited.

MR. JAMES W. WRIGHT and Mr. William Caddick, of the sales department of the Cannon Iron Foundries, Limited, Deepfields, Bilston, have just completed 50 years each in the service of the company.

MR. JOHN GREEN and MR. R. J. CAVILL have been appointed local directors of Thos. Firth & John Brown, Limited, Sheffield. Mr. Green is in charge of all labour matters and other activities associated with the company, while Mr. Cavill is commercial manager of the heavy forge department.

PROF. J. HUSBAND, M.Inst.C.E., who retired from the chair of civil engineering at Sheffield University last year, has been elected President of the Institution of Structural Engineers. Prof. Husband is senior partner in the firm of Husband & Clark, chartered civil and structural engineers, of Sheffield.

SIR PAUL M. BOOTH, a director of Booth & Brookes, Limited, ironfounders, of Burnham-on-Crouch, is to be the guest of the National Liberal Club at a Complimentary Dinner on June 16, to celebrate the honour of Knighthood conferred upon him by His Majesty, and to recognise his long and valuable service as chairman of the management committee of the Club. Lord Meston is to preside.

SIR ERNEST PETTER and Mr. P. W. Petter, owing to increasing age, have found it necessary to resign from the chairmanship and vice-chairmanship, and also from the board of Petters, Limited. Mr. W. A. Phillip, Mr. T. A. Macauley and Col. J. T. C. Moore-Brabazon, M.P., have also retired from the board. Mr. A. P. Good, Mr. Charles Hill and Mr. T. B. Keep have been elected to the board. Mr. A. P. Good has been elected chairman and Mr. T. B. Keep has been appointed managing director of the company.

MR. R. S. HUDSON has been appointed secretary of the Department of Overseas Trade, in succession to Capt. Euan Wallace, who goes to the Board of Trade as Parliamentary Secretary. Mr. Hudson began his career in the Diplomatic Service and entered Parliament for Whitehaven in 1924. Since 1931 he has represented Southport, and in that year he became Parliamentary Secretary to the Ministry of Labour. When Mr. Ramsay MacDonald resigned the Premiership, Mr. Hudson succeeded Major Tryon as Minister of Pensions. In the redistribution of under-secretaryships in August last year he was appointed Parliamentary Secretary to the Ministry of Health, in addition to which he represented the Office of Works in the Commons.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Northern Refractories, Limited. — Capital, £100. Subscriber: T. H. Lancaster, 109, Kingsley Road, South Harrow.

Scottish Refractories, Limited. — Capital, £100. Subscriber: T. H. Lancaster, 109, Kingsley Road, South Harrow.

North-Eastern Refractories, Limited. — Capital, £100. Subscriber: T. H. Lancaster, 109, Kingsley Road, South Harrow.

Rothschild Metals, Limited. — Capital, £10,000. Dealers in metals and ores, etc. Director: H. Rothschild. Subscriber: W. E. Wolff, 1/2, Finsbury Square, London, E.C.2.

Company Meeting

British Oxygen Company, Limited

The annual meeting of the British Oxygen Company, Limited, was held in London on May 26. DR. J. DONALD POLLOCK (chairman) said that the extension and modernisation of their plant and equipment works at Edmonton was completed during the year, and they were now enjoying the benefit of these extensions, which enabled them to cope with the increasing demands for plant and equipment of all kinds for use in the application of their products. The company's programme, which was commenced in 1930, of laying down large-capacity oxygen-producing plants in the chief industrial centres throughout the country, made further progress during the year, and their main chain of these large plants now operated from London to Glasgow. The demand for acetylene equally showed a continuous expansion. Acetylene was manufactured from calcium carbide, and the supplies of carbide for this country were wholly imported. The Government had now set up a Calcium Carbide Committee, which was prepared to consider schemes which might be submitted to it for the production of calcium carbide, and the company proposed to submit a scheme to the Committee. The expansion of the welding business continued during the year in both the oxy-acetylene and electric systems. The two systems tended to be more closely allied, and the directors were of the opinion that, rather than still further extend the electric-welding department of the company, it would be better to ally themselves with an old-established company engaged in electric-welding development. They had purchased the share capital of the Quasi-Arc Company, Limited, and of the Ferro-Arc Welding Company, and the amalgamation of these interests allowed them to group the technical resources of oxy-acetylene and electric welding and to place their organisation in a position to give unbiassed information on welding and welding problems.

Contracts Open

Blackpool, June 17.—48 in. dia. and 36 in. dia. cast-iron pipes and special pipes, for the Town Council. The Borough Surveyor, Talbot Square.

Cairo, June 15.—Iron and steel pipes, for the Director-General, Main Drainage Department, No. 4, Sharia El Antikkhana. The Stores Office, Sharia El Maleka Nazli, No. 10, Cairo. (Fee 130 mills., non-returnable.)

Cairo, July 5.—Pumping station, consisting of transformers, pumps, motors, switchboard, etc.; 2,600 metres rising main pipe line of 14 in. dia., with valves, accessories, etc.; transformer substation, switchboard, etc., for the Director-General, Mechanical and Electrical Department, Ministry of Public Works. The Chief Inspecting Engineer of the Egyptian Government, 41, Tothill Street, London, S.W.1. (Fee £E2, plus 60 mills.)

Douglas, I.O.M., June 12.—Iron and steel, for the Town Council. The Borough Surveyor, Town Hall, Douglas, I. of M.

Company Reports

Summerlee Iron Company, Limited.—Dividend of 3s. per share, or 120 per cent., less tax, on the ordinary shares.

Mason & Burns, Limited.—Profit for year ended March 31, after depreciation, £10,271; tax, £1,750; dividend of 12 per cent. actual (equal to 17.66 per cent. per annum); carried forward, £432.

Darwins, Limited.—Net profit for year ended March 31, £13,040; brought in, £13,602; balance at credit of profit and loss account of £26,642 is carried to general reserve in view of the pending reorganisation of capital.

Forthcoming Events

Institute of British Foundrymen

JUNE 8 TO 11.
Thirty-fourth Annual Conference in Derby.

JUNE 17 TO 24.
International Foundry Congress in Paris.

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Raw Material Markets

The Central Pig-iron Producers' Association has announced that prices of forge and foundry pig-iron for the second half of the year are to be subject to an advance of £1 a ton. An exception is made for the Scottish zone as to the duration of the new prices, it being intimated that they may be reviewed there as from September 30 next. Little surprise has been occasioned by the increased quotations as far as they go, but, in some quarters, suggestions had been made that a loyalty rebate scheme similar to that now in operation for sales of hematite and basic irons would be adopted. The rising costs of production made higher prices inevitable and the prospect of an advance of 5 per cent. in railway rates has further strengthened the producers' case. The position with regard to supplies over the second half of the year is difficult to determine, as the tonnage available will depend solely on productive capacity, stocks being entirely cleared. As a result, most makers will accept new business only for the third quarter.

Pig-Iron

MIDDLESBROUGH.—Fairly substantial tonnages of Continental iron have had to be imported recently in order to relieve the shortage of home-produced material. Producers are not expected to have any considerable tonnage for disposal over the second half of the year, as supplies will be required to reduce arrears on previous contracts. For the time being, at any rate, producers will restrict new orders for deliveries up to the end of September. The revised price of No. 3 Cleveland G.M.B. foundry iron is 101s. per ton, delivered in the Middlesbrough area. In addition to the very heavy home demand for hematite, there also is a large number of inquiries from the Continent and substantial premiums are offered from this source. Prices are based on East Coast hematite mixed numbers at 122s. 6d. per ton on the North-East Coast, 128s. in Sheffield and 133s. 6d. in Birmingham, less the usual rebate of 5s. per ton.

LANCASHIRE.—For delivery to users in the Lancashire price zone after the end of this month, Derbyshire and Staffordshire brands of No. 3 foundry iron are quoted at 109s. per ton, with Northants at 107s. 6d., and Derbyshire forge iron at 104s. to 106s., according to the class of consumer. It is hoped that the publication of the new figures will facilitate the transaction of more business, as consumers are being seriously inconvenienced by the lack of material. West Coast hematite is quoted at 131s., with East Coast material at 130s. 6d. Deliveries are difficult to secure and are well behind schedule. Only small tonnages of Scottish No. 3 foundry iron are obtainable at around 135s. per ton, delivered equal to Manchester.

MIDLANDS.—Northants No. 3 foundry iron is quoted at 103s. 6d. for delivery in the second half of the year with Derbyshire, Lincolnshire and North Staffordshire No. 3 at 106s., less 5s. per ton for forge iron for puddling purposes, and including delivery to Birmingham and Black Country stations. These prices are according to expectations, but it is unlikely that much new business will be capable of acceptance, as most furnaces have heavy delivery arrears to delete. The chief hope lies in Northamptonshire, producers in that county not being so extensively committed as the Derbyshire makers. Supplies of low-phosphorus iron are difficult to procure at from £6 10s. to £7, delivered the Midlands. Refined iron is quoted at from £7 15s. to £8 10s. A fair amount of business has recently been put through for the second half of the year in hematite, but producers are keeping a close watch on the position. For delivery to Midland stations, West Coast mixed numbers are quoted at £6 14s. 6d. and East Coast material at £6 13s. 6d. per ton, subject to 5s. rebate in each case.

SCOTLAND.—Pig-iron consumers in this area are much handicapped by the shortage of supplies and there seems little prospect of any immediate alleviation of the situation. Official prices are 115s. 6d. for No. 1 foundry and 113s. for No. 3, f.o.t. furnaces. No. 3 Cleveland iron is quoted at 104s. f.o.t. Falkirk and 107s. f.o.t. Glasgow, for deliveries after the end of the current month. These prices may come up for further consideration at the end of September. Mixed numbers of hematite are unchanged at the recently-advanced figures of 123s., with British basic iron at 107s. 6d. and Indian basic at 100s. per ton, all delivered steelworks and less 5s. rebate.

Coke

Supplies of foundry coke are still restricted. For delivery to Birmingham and district, best Durham coke is officially quoted at 46s. 6d., but premium prices have to be paid. Welsh coke is at 47s. 6d. to 60s. per ton, according to quantity and quality.

Steel

The steel market has developed a rather quieter tone owing to the inability of the producers to add continually to their crowded order-books, states the official report of the London Iron and Steel Exchange. In all departments of the steel trade, production is being pressed to its utmost, and if the volume of new business is less than in the early part of the year it is because of the difficulty of finding a manufacturer in a position to accept orders for execution before the fourth quarter. In the semi-finished steel market, the pressure to secure delivery is unabated, and, while some improvement is noticeable in supplies of Continental semi-finished steel, there are still heavy arrears of deliveries to make up. New business in the finished steel section is almost entirely confined to dealings for delivery in the last quarter of the year. It would appear, however, that gradually some impression is being made upon arrears in deliveries. Inquiry upon export account is active, but, owing to the need of meeting home trade requirements, only a proportion of the business offering can be accepted.

Scrap

Supplies of some qualities of scrap appear to be rather more plentiful as a result of the scheme stabilising the prices of steel scrap, and a better tonnage has changed hands in most districts. The demand remains well in excess of the supply, however, and consumers would willingly pay higher prices if the material could be procured. Prices in all districts are very firm. Consuming plants are inconvenienced by the inadequate deliveries. Every available melting furnace at the steelworks seems to be in operation. Ironfoundries in some cases now appear to be getting better deliveries of cast-iron scrap.

Metals

Although it was generally believed last week that the gold scare had abated, it would appear that this was only of a temporary nature, and on Saturday the volume of gold on the market was extraordinarily heavy for a Saturday morning. Reports from New York are still emphatic that no price alteration will be made as far as gold is concerned. Another factor which has continued to cause much uncertainty in the commodity markets is the much-criticised National Defence Contribution scheme, which has received as much opposition as any political measure for a long time past, practically all industries having registered protests. Mr. Chamberlain's primary concessions were hardly regarded as such, but his decision to introduce "a new and simpler tax on the profits of industry" modelled on the old Corporation Profits Duty has been accorded a much better reception.

Copper.—Quieter conditions have prevailed in this market during the past week and prices displayed a downward tendency early on. Fairly good business has gone through in the United States. Brandeis, Goldschmidt & Company, Limited, in their weekly market report, state that a peculiar position has arisen in the market owing to producers trying to secure the present price for copper as far forward as possible, while consumers, who are made rather nervous by this action, are only buying from hand to mouth. This explains to some extent the heavy backwardation existing at present, in spite of the fact that stocks ample for market purposes are still lying in English warehouses. Prices have been pretty well maintained and the firm still have the conviction that copper is not dear and that we shall see the present price level—and may be even a higher one—for some considerable time to come.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £61 to £61 5s.; Friday, £60 5s. to £60 10s.; Monday, £58 to £58 2s. 6d.; Tuesday, £59 15s. to £60; Wednesday, £61 2s. 6d. to £61 5s.

Three Months.—Thursday, £58 17s. 6d.; to £59; Friday, £58 5s. to £58 7s. 6d.; Monday, £57 3s. 9d. to £57 5s.; Tuesday, £58 5s. to £58 7s. 6d.; Wednesday, £59 7s. 6d. to £59 12s. 6d.

Tin.—While business in this country has again been on quiet lines, the United States has bought larger tonnages. The May issue of The Hague Statistical Bulletin of the International Tin Research and Development Council, indicates that world apparent consumption of tin in March, 1937, was over 19,000 tons, against 14,600 tons in February. Consumption in the first quarter of the year was 49,432 tons, against 39,999 tons in the corresponding period of 1936. World production of tinplates totalled 1,017,000 tons in January-March, 1937, as compared with 813,000 tons in the first quarter of 1936. Thus, tinplate production increased by 25 per cent. during this period. It is understood that a new company is in process of incorporation to develop and work the Royal Polberro tin deposits in the St. Agnes district of Cornwall.

Official quotations were as follow :—

Cash.—Thursday, £249 15s. to £250; Friday, £248 15s. to £249; Monday, £245 15s. to £246; Tuesday, £249 5s. to £249 10s.; Wednesday, £255 to £255 5s.

Three Months.—Thursday, £248 15s. to £249; Friday, £247 17s. 6d. to £248; Monday, £244 15s. to £245; Tuesday, £248 to £248 5s.; Wednesday, £254 to £254 5s.

Spelter.—There is little of interest to report about the trend of this market at the present time and the tone generally is dull. The outlook is uncertain and consumers obviously are awaiting a clearer view of the future before committing themselves.

Daily market prices :—

Ordinary.—Thursday, £22 17s. 6d.; Friday, £22 15s.; Monday, £22 2s. 6d.; Tuesday, £22 15s.; Wednesday, £23 10s.

Lead.—Featureless conditions have also prevailed in this market and business has been of small dimensions. According to the American Bureau of Metal Statistics, stocks of refined lead at the end of April totalled 128,500 tons, compared with 137,000 tons at the end of March. Production during the month totalled 46,500 tons, against 43,600 tons.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £23 15s.; Friday, £24; Monday, £23 8s. 9d.; Tuesday, £23 17s. 6d.; Wednesday, £24 8s. 9d.

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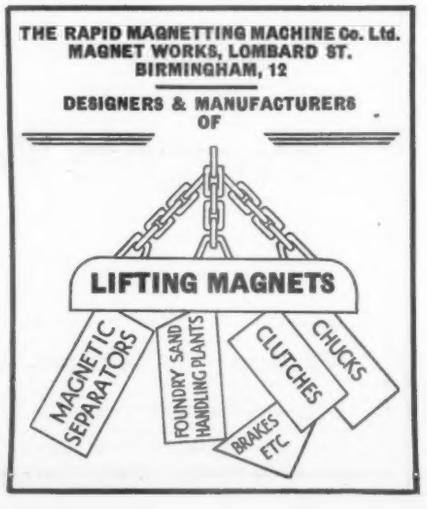

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Genefax House, Sheffield

Telephone : *Sheffield 31113 (6 lines).*

Telegrams : *"Genefax, Sheffield."*

LONDON OFFICE: Russell House, Adelphi, W.C.2.
Telephone: Temple Bar 7361. Telegrams: "Genefax, Rand-London." Mr. A. C. Turner.

SCOTTISH OFFICE: 48, West Regent Street, Glasgow. Telephone: 3009. Telegrams: "Genefax, Glasgow." (Mr. C. A. G. Thomson.)

MANCHESTER OFFICE: 9, Albert Square, Manchester, 2. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell.)

SWANSEA OFFICE: Metropole Chambers, Wind Street, Swansea. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. Hood-Williams.)

CARDIFF OFFICE: 17, Windsor Place, Cardiff. Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter.)

MIDDLESBROUGH OFFICE: Halifax Buildings, Exchange Place.
Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough."

★

Read what an IMPORTANT STEELFOUNDER says :—

"During the 40 years I have been connected with Steel Foundry work, considerable changes have taken place. Away back, we had Steel Moulders' Composition, Old Crucible Pots, etc., and each works claimed to have its own 'secret' moulding composition. High Silica Sand has eliminated practically all these from many foundries and to-day we have your 'Yorkshire Sand' which acts almost like a chill, and leaves the skin of the casting blue-black and as clean as cast iron.

The hot steel lies quietly against the wall of sand, and often when the casting has been lifted out of the mould, the latter looks as if it could be used over again, just like a permanent mould."

RAW MATERIALS—PRICE LIST

(Wednesday, June 2, 1937)

COPPER

	£	s.	d.
Standard cash	61	2	6
Three months	59	7	6
Electrolytic	64	0	0
Tough	64	12	6
Best selected	65	2	6
Sheets	94	7	6
India	77	17	6
Wire bars	66	7	6
Ingot bars	66	7	6
H.C. wire rods	69	17	6
Off. av. cash, May	61	4	$8\frac{1}{16}$
Do., 3 mths., May	58	6	$4\frac{7}{32}$
Do., Sttlmnt., May	61	3	$5\frac{3}{16}$
Do., Electro, May	64	13	$5\frac{1}{16}$
Do., B.S., May	65	0	0
Do., wire bars, May	65	13	$1\frac{7}{16}$
Solid drawn tubes			$14\frac{1}{2}$d.
Brazed tubes			$14\frac{1}{2}$d.
Wire			$10\frac{1}{2}$d.

BRASS

Solid drawn tubes	$12\frac{1}{2}$d.
Brazed tubes	$14\frac{1}{2}$d.
Rods, drawn	11d.
Rods, extd. or rlld.	$7\frac{1}{2}$d.
Sheets to 10 w.g.	$10\frac{1}{2}$d.
Wire	$10\frac{1}{2}$d.
Rolled metal	$9\frac{1}{2}$d.
Yellow metal rods	$7\frac{1}{4}$d.

TIN

	£	s.	d.
Standard cash	255	0	0
Three months	254	0	0
English	255	5	0
Bars	257	0	0
Straits	256	10	0
Eastern	253	5	0
Banca (nom.)	256	10	0
Off. av. cash, May	250	16	$11\frac{13}{16}$
Do., 3 mths., May	248	12	$8\frac{7}{16}$
Do., Sttlmt., May	250	16	$10\frac{3}{16}$

SPELTER

	£	s.	d.
Ordinary	23	10	0
Remelted	21	0	0
Hard	21	0	0
Electro, 99.9	26	1	3
English	24	10	0
India	20	0	0
Zinc dust	32	0	0
Zinc ashes	8	15	0
Off. aver., May	23	4	$6\frac{13}{32}$
Aver. spot, May	23	1	$10\frac{3}{16}$

LEAD

	£	s.	d.
Soft foreign, ppt.	24	8	9
Empire (nom.)	24	12	6
English	26	10	0
Off. aver., May	23	18	$10\frac{17}{32}$
Aver. spot, May	24	0	0

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	35	10	0 to	36	0	0
Do., V.M. ex-whse.	35	10	0 to	36	0	0
Rods				29	10	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	82	10	0 to	83	10	0
Chinese, ex-whse.				69	0	0
Crude, c.i.f.				38	0	0

QUICKSILVER

	£	s.	d.
Quicksilver	14	18	3

FERRO-ALLOYS AND STEEL-MAKING METALS

	£	s.	d.	£	s.	d.
Ferro-silicon—						
25%	13	0	0 to	14	10	0
45/50%	10	15	0 to	12	0	0
75%	15	15	0 to	17	0	0
Ferro-vanadium—						
35/50%				12/8 lb. Va		
Ferro-molybdenum—						
70/75% carbon-free				4/9 lb. Mo.		
Ferro-titanium—						
20/25% carbon-free				9d. lb.		
Ferro-phosphorus, 20/25%				£21 to £22		
Ferro-tungsten—						
80/85%				5/- lb. (nom.)		
Tungsten metal powder—						
98/99%				5/3 lb. (nom.)		
Ferro-chrome—						
2/4% car.				32	17	6
4/6% car.				22	10	0
6/8% car.				21	10	0
8/10% car.				21	10	0
Ferro-chrome—						
Max. 2% car.				32	10	0
Max. 1% car.				35	15	0
Max. 0.5% car.				36	10	0
70% carbon-free				9½d. lb.		
Nickel—99.5/100%				£180 to £185		
"F" nickel shot				£165	0	0
Ferro-cobalt, 98/99%				7/3 lb.		
Metallic chromium—						
96/98%				2/5 lb.		
Ferro-manganese—						
76/80% loose	£16	15	0 to	17	5	0
76/80% packed	£17	15	0 to	18	5	0
76/80% export				£20	0	0
Metallic manganese—						
94/96% carbon-free				1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten 2s. 7d.
Finished bars, 18% tungsten 3s. 6d.
Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ⅛ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ¼ in. × ⅛ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	7	6 to	3	10	0
Mixed iron and steel	3	5	0 to	3	7	6
Heavy cast iron	3	8	0 to	3	10	0
Good machinery	3	17	6 to	4	2	6
Cleveland—						
Heavy steel, best	3	6	6 to	3	9	0
Steel turnings				2	12	6
Heavy cast iron				4	5	0
Heavy machinery				4	7	6
Midlands—						
Short heavy steel	3	15	0 to	4	0	0
Light cast-iron scrap				3	2	6
Heavy wrought iron	3	17	6 to	4	2	6
Steel turnings	2	2	6 to	2	5	0
Scotland—						
Heavy steel, best	3	4	6 to	3	7	0
Ordinary cast iron				4	10	0
Cast-iron borings	2	0	0 to	2	2	6
Wrot-iron piling	4	5	0 to	4	7	6
Heavy machinery				4	15	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	47	0	0
Brass	30	0	0
Lead (less usual draft)	19	10	0
Tea lead	13	0	0
Zinc	14	0	0
New aluminium cuttings	74	0	0
Braziery copper	42	0	0
Gunmetal	44	0	0
Hollow pewter	160	0	0
Shaped black pewter	115	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—

Foundry No. 1	83/6
,, No. 3	81/-
,, No. 4	80/-
Forge No. 4	80/-
Hematite No. 1	123/-*
Hematite M/Nos.	122/6*

N.W. Coast—

Hem. M/Nos. d/d Glas.	123/-*
,, d/d Birm.	134/6*
Malleable iron d/d Birm.	160/-

Midlands (d/d Birmingham dist.)—

Staffs No. 4 forge	83/-
,, No. 3 fdry.	86/-
Northants forge	80/6
,, fdry. No. 3	83/6
,, fdry. No. 1	86/6
Derbyshire forge	83/-
,, fdry. No. 3	86/-
,, fdry. No. 1	89/-

Scotland—

Foundry, No. 1, f.o.t.	115/6
,, No. 3, f.o.t.	113/-
Cleveland No. 3, Glasgow	87/-
,, ,, Falkirk	84/-
Scottish hem. M/Nos. d/d	123/-*

Sheffield (d/d district)—

Derby forge	80/6
,, fdry. No. 3	83/6
Lincs forge	80/6
,, fdry. No. 3	83/6
W.C. hematite	128/6*

Lancashire (d/d eq. Man.)—

Derby fdry. No. 3	89/-
Staffs fdry. No. 3	89/-
Northants fdry. No. 3	87/6
Cleveland fdry. No. 3	89/-
Glengarnock, No. 3	135/-
Clyde, No. 3	135/-
Monkland, No. 3	135/-
Summerlee, No. 3	135/-
Eglinton, No. 3	135/-
Gartsherrie, No. 3	135/-
Shotts, No. 3	135/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumers' station for steel.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)				11	17	6
Nut and bolt iron	10	5	0 to	10	15	0
Hoops				12	15	0
Marked bars (Staffs) f.o.t.				14	7	6
Gas strip				12	15	0
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up.
Steel—						
Plates, ship, etc.	11	8	0 to	11	10	6
Boiler plts.	11	18	0 to	12	0	6
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to 5½ in.				12	0	6
Rounds under 3 in. to ⅜ in. (Untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				19	10	0
Galv. flat shts. (,,)				20	0	0
Galv. fencing wire, 8g. plain				17	10	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	14½d.
Wire	15½d.
Rods	15½d.
Tubes	20½d.
Castings	16d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	95.00
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.15
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb box	$5.35

COKE (at ovens)

Welsh foundry	32/- to 33/-
,, furnace	27/- to 28/-
Durham foundry	34/6
,, furnace	32/6
Scotland foundry	—
,, furnace	28/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	24/6 to 25/6
,,	28×20 ,,	49/- to 51/-
,,	20×10 ,,	34/6 to 35/6
,,	18¾×14 ,,	24/9 to 25/9
C.W.	20×14 ,,	22/- to 23/-
,,	28×20 ,,	45/- to 46/6
,,	20×10 ,,	31/- to 32/6
,,	18¾×14 ,,	23/- to 25/-

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£12	0	0 to	£13	0	0
Bars-hammered, basis	£20	0	0 to	£21	0	0
Bars and nail-rods, rolled, basis	£19	0	0 to	£20	0	0
Blooms	£16	0	0 to	£17	0	0
Keg steel	£27	0	0 to	£30	0	0
Faggot steel	£20	0	0 to	£25	0	0
Bars and rods dead soft st'l	£19	0	0 to	£20	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

			£	s.	d.		
May	27	..	61	0	0	dec.	10/-
,,	28	..	60	5	0	,,	15/-
,,	31	..	58	0	0	,,	45/-
June	1	..	59	15	0	inc.	35/-
,,	2	..	61	2	6	,,	27/6

Electrolytic Copper

			£	s.	d.		
May	27	..	64	0	0	dec.	10/-
,,	28	..	64	0	0	No change	
,,	31	..	62	0	0	dec.	40/-
June	1	..	64	0	0	inc.	40/-
,,	2	..	64	0	0	No change	

Standard Tin (cash)

			£	s.	d.		
May	27	..	249	15	0	dec.	45/-
,,	28	..	248	15	0	,,	20/-
,,	31	..	245	15	0	,,	60/-
June	1	..	249	5	0	inc.	70/-
,,	2	..	255	0	0	,,	115/-

Tin (English ingots)

			£	s.	d.		
May	27	..	249	15	0	dec.	45/-
,,	28	..	248	15	0	,,	20/-
,,	31	..	245	15	0	,,	60/-
June	1	..	249	5	0	inc.	70/-
,,	2	..	255	5	0	,,	120/-

Spelter (ordinary)

			£	s.	d.		
May	27	..	22	17	6	dec.	10/-
,,	28	..	22	15	0	,,	2/6
,,	31	..	22	2	6	,,	12/6
June	1	..	22	15	0	inc.	12,6
,,	2	..	23	10	0	,,	15/-

Spelter (Electro, 99.9 per cent.)

			£	s.	d.		
May	27	..	25	10	0	dec.	10/-
,,	28	..	25	7	6	,,	2/6
,,	31	..	24	12	6	,,	15/-
June	1	..	25	6	3	inc.	13/9
,,	2	..	26	1	3	,,	15/-

Lead (soft foreign, prompt)

			£	s.	d.		
May	27	..	23	15	0	dec.	12/6
,,	28	..	24	0	0	inc.	5/-
,,	31	..	23	8	9	dec.	11/3
June	1	..	23	17	6	inc.	8/9
,,	2	..	24	8	9	,,	11/3

Lead (English)

			£	s.	d.		
May	27	..	25	15	0	inc.	10/-
,,	28	..	26	0	0	,,	5/-
,,	31	..	25	10	0	dec.	10/-
June	1	..	25	15	0	inc.	5/-
,,	2	..	26	10	0	,,	15/-

AVERAGE MONTHLY PRICES OF STEEL BOILER PLATES IN ENGLAND

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1900	9 5 0	9 5 0	9 7 6	9 10 0	9 12 6	10 5 0	10 5 0	10 5 0	10 5 0	10 0 0	9 15 0	9 15 0	9 15 10
1901	9 5 0	9 5 0	8 15 0	8 10 0	8 10 0	7 10 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 3 11
1902	7 7 6	7 0 0	7 12 6	7 12 6	7 12 6	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 9 7
1903	7 10 0	7 10 0	7 15 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 3 11½
1904	6 12 6	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	6 17 6	7 0 0	7 0 0	7 0 0	7 0 0	6 17 6	7 0 0
1905	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 10 0	7 5 0	8 0 0	8 0 0	7 1 3
1906	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 10
1907	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 10 0	8 8 4
1908	7 10 0	7 10 0	7 10 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	8 0 0	7 3 9
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 15 0	6 15 0	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 9
1910	7 0 0	7 0 0	7 1 3	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 5 1
1911	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 4
1912	7 18 9	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 15 0	8 16 3	9 0 0	9 2 0	9 5 0	8 11 2½
1913	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	8 19 0	8 15 0	8 5 0	7 15 0	7 15 0	8 17 0
1914	7 15 0	7 15 0	7 15 0	7 13 9	7 10 6	7 5 0	7 0 0	8 0 0	8 2 6	8 5 0	8 5 0	8 5 0	7 15 11½
1915	8 14 0	9 10 0	9 17 6	10 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 4 0	12 0 0	13 0 0	10 15 5½
1916	13 0 0	13 0 0	13 0 0	12 15 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 12 11
1917	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1918	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1919	13 0 0	15 0 0	15 0 0	15 0 0	19 5 0	19 17 6	21 0 0	21 10 0	21 10 0	21 10 0	21 15 0	23 10 0	18 9 9
1920	26 0 0	28 0 0	28 5 0	28 10 0	29 5 0	30 0 0	30 0 0	30 0 0	30 10 0	31 0 0	31 0 0	31 0 0	29 9 2
1921	30 5 0	29 0 0	25 0 0	25 0 0	25 0 0	23 0 0	21 0 0	20 10 0	19 0 0	17 10 0	16 0 0	14 16 0	22 1 9
1922	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	13 1 8	13 10 0	12 15 0	12 10 0	12 10 0	12 10 0	12 6 0	13 10 9
1923	12 8 9	13 6 0	14 0 0	14 0 0	14 0 0	14 0 0	13 12 6	13 0 0	13 0 0	12 0 0	13 0 0	13 10 0	13 9 1½
1924	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	14 0 0	14 0 0	13 11 0	13 5 0	13 5 0	13 10 11
1925	13 5 0	13 5 0	13 5 0	13 1 0	12 15 0	12 15 0	12 15 0	12 15 0	12 7 6	11 14 0	11 10 0	11 10 0	12 11 5½
1926	11 10 0	11 10 0	11 10 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 6	11 6 8
1927	11 5 0	11 5 0	11 5 0	11 5 0	11 2 6	11 0 0	11 0 0	11 0 0	10 16 0	10 10 0	10 10 0	10 10 0	10 10 0½
1928	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0
1929	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 5 0	10 1 3	10 1 3	10 1 3	10 1 7	10 6 8½
1930	10 2 9	10 3 5½	10 3 9	10 3 9	10 3 6	10 2 6	10 2 6	10 2 6	10 2 2½	9 19 6	9 16 3	9 16 3	10 1 6½
1931	9 15 0	9 15 0	9 15 0	9 10 11	9 6 9	9 5 0	9 7 0	9 7 9½	9 8 9	9 5 9	9 5 6	9 9 6	9 9 4
1932	9 5 0	9 2 6	8 18 6	8 17 6	8 16 6½	8 16 3	8 16 3	8 16 3	8 16 3	8 16 3	8 16 3	8 16 3	8 17 10
1933	8 10 0	8 10 0	8 10 0	8 8 9	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 6 0	8 7 6	8 8 10½
1934	8 8 1½	8 10 7½	8 16 6	8 17 6	8 6 3	8 6 3	8 5 7½	8 5 0	8 5 0	8 5 0	9 6 3	9 6 3	8 11 6½
1935	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3	9 6 3
1936	9 6 3	9 6 3	9 6 3	9 6 3	9 9 4½	9 18 9	9 18 9	9 18 9	9 18 9	9 18 9	9 18 9	9 19 4	9 13 10½
1937	10 1 9	10 1 9	10 1 9	10 1 9	11 19 3	—	—	—	—	—	—	—	—

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